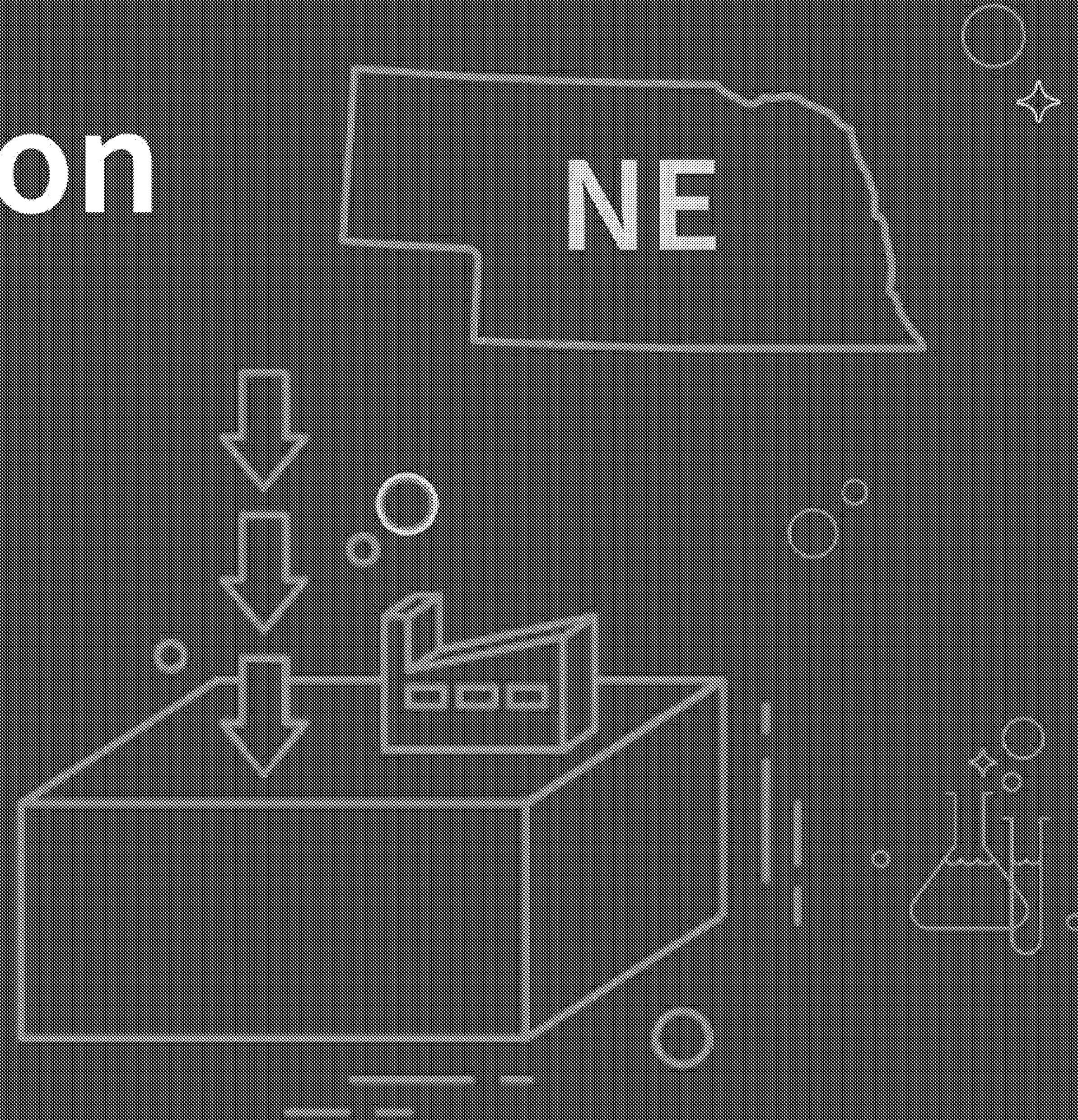
Capturing Carbon in Nebraska Webinar Series

Webinar #2 | Case Studies



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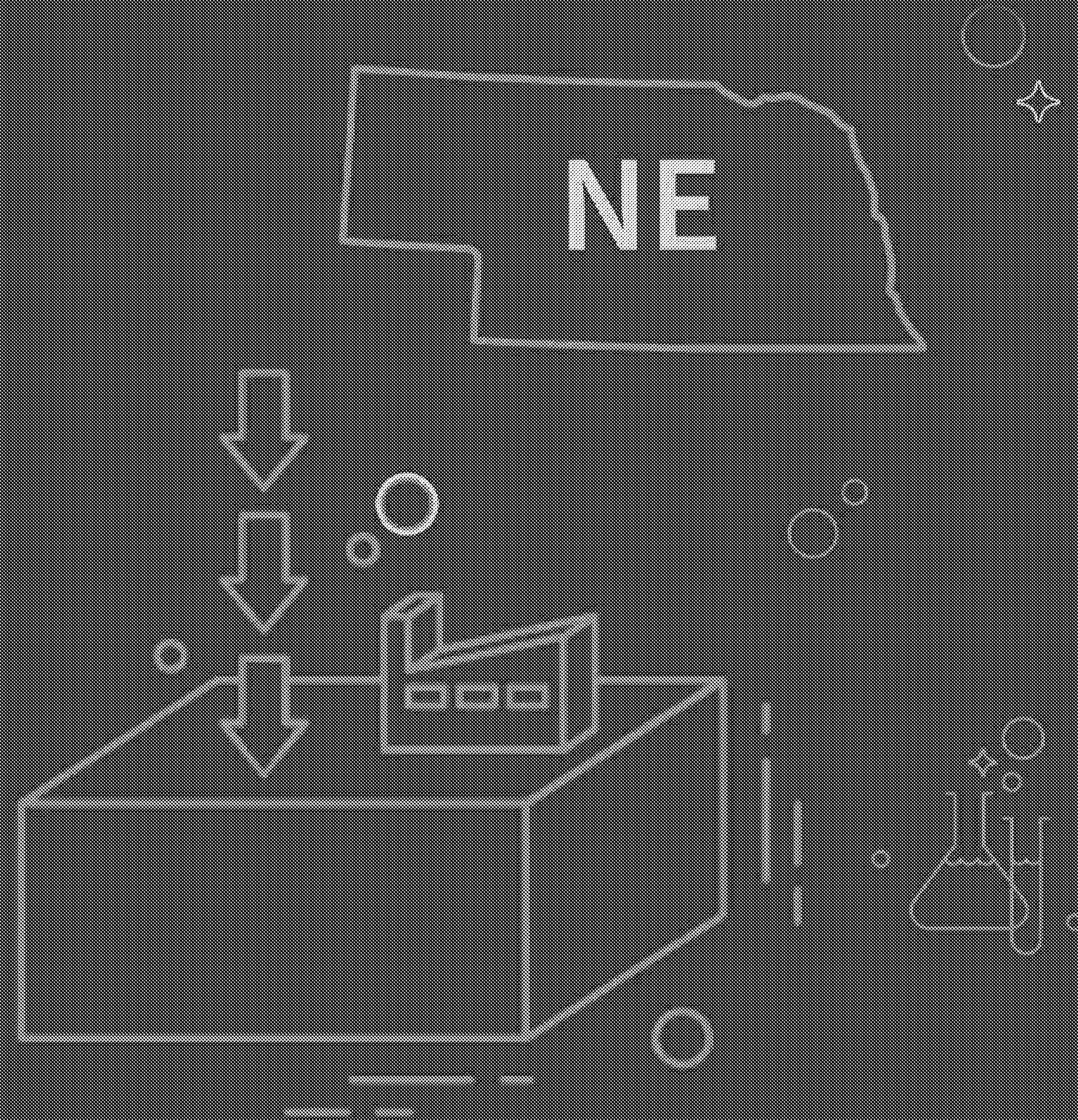
CO-HOSTS

- Battelle
- Nebraska Conservation and Survey Division
- Nebraska Ethanol Board
- Nebraska Public Power District
- Regional Deployment Initiative
- Renewable Fuels Nebraska



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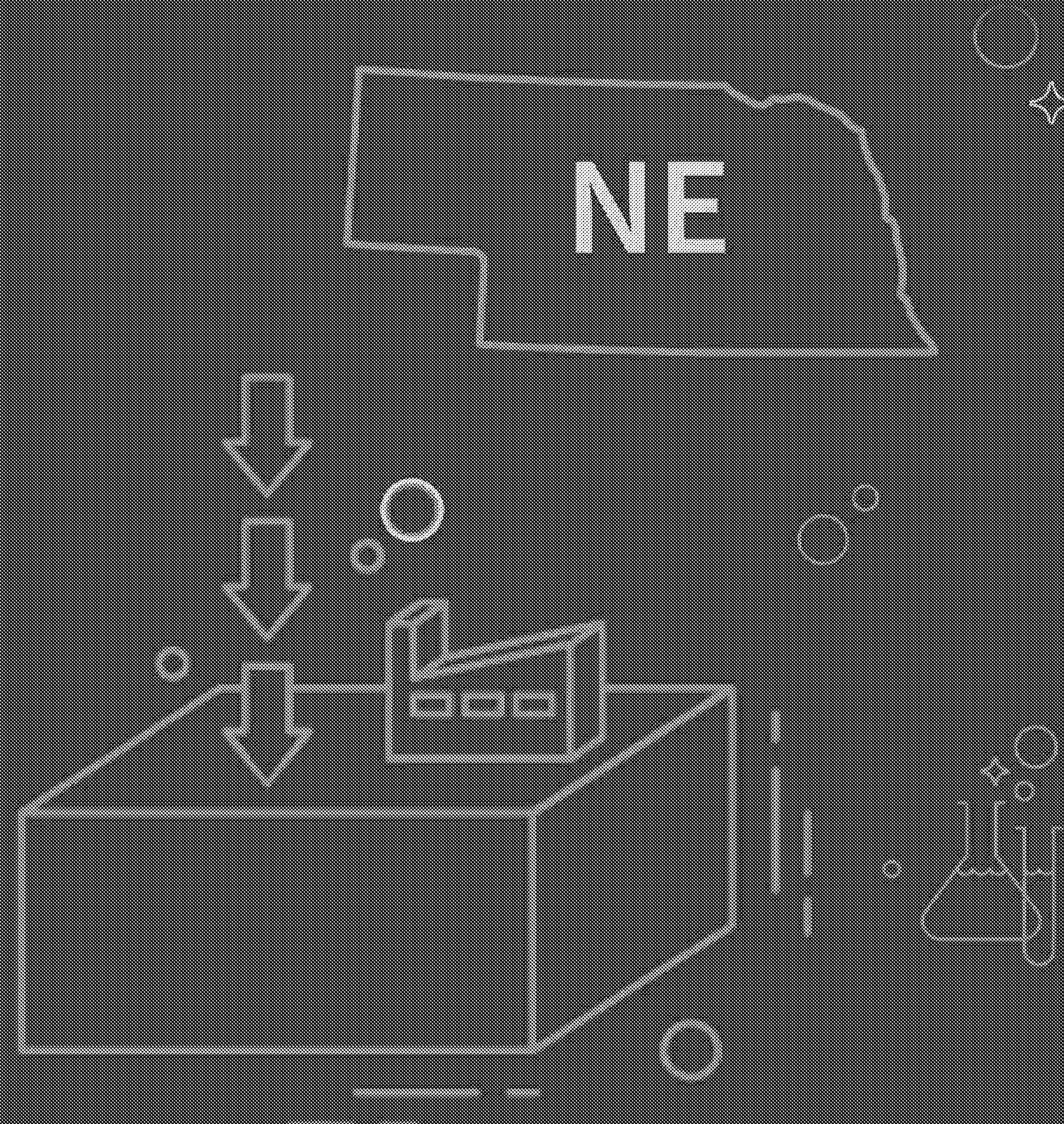
OVERVIEW

- **Carbon Capture Economics**
  - Andrew Duguid, Battelle
- **Carbon Capture at Nebraska Public Power District**
  - John Swanson, NPPD
- **Ethanol-based Economic Carbon Capture**
  - Keith Tracy
- **CO_2 Transport and Sequestration Infrastructure**
  - Ryan Edwards, Occidental Petroleum
- **Question and Answer**



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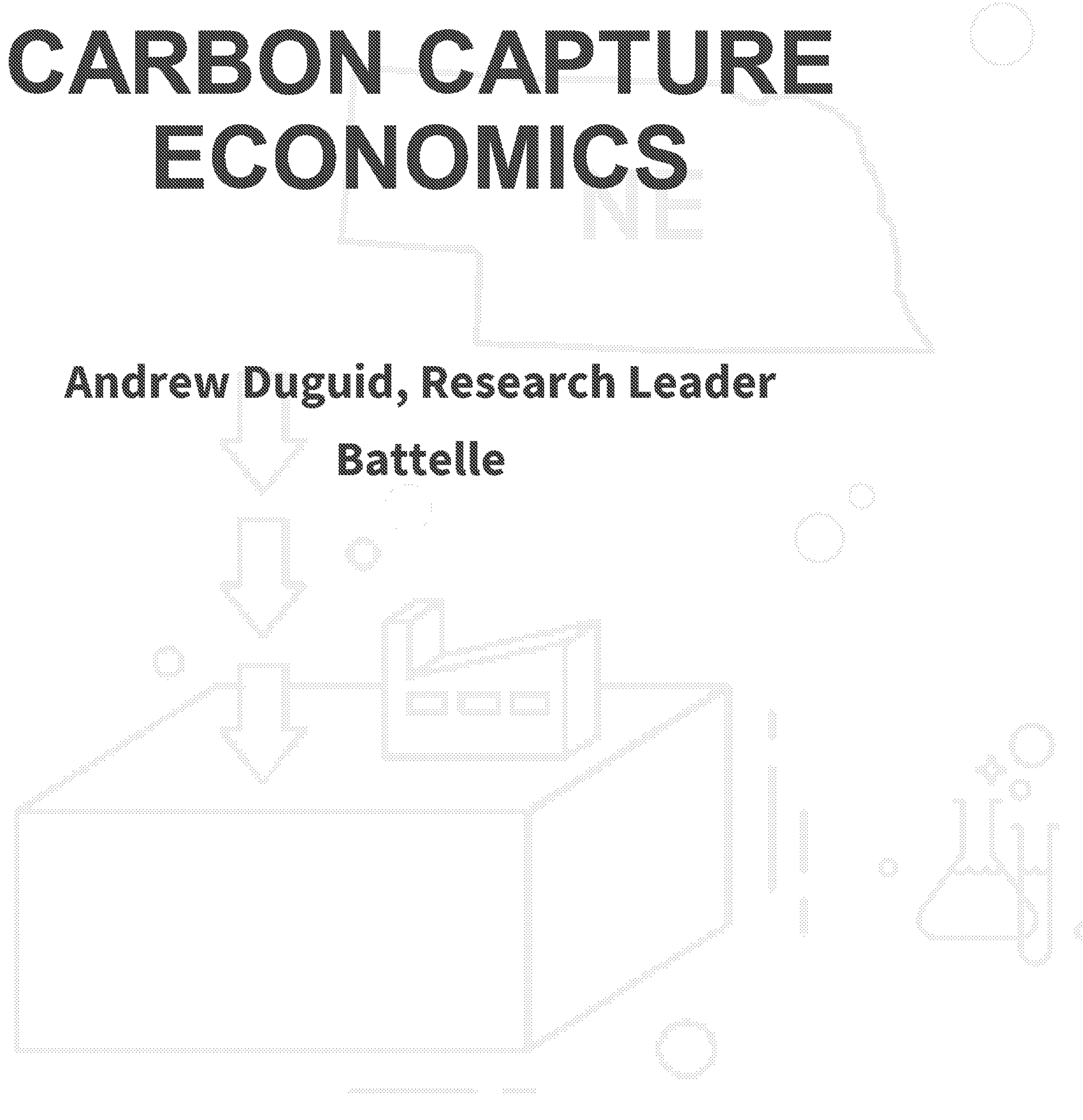
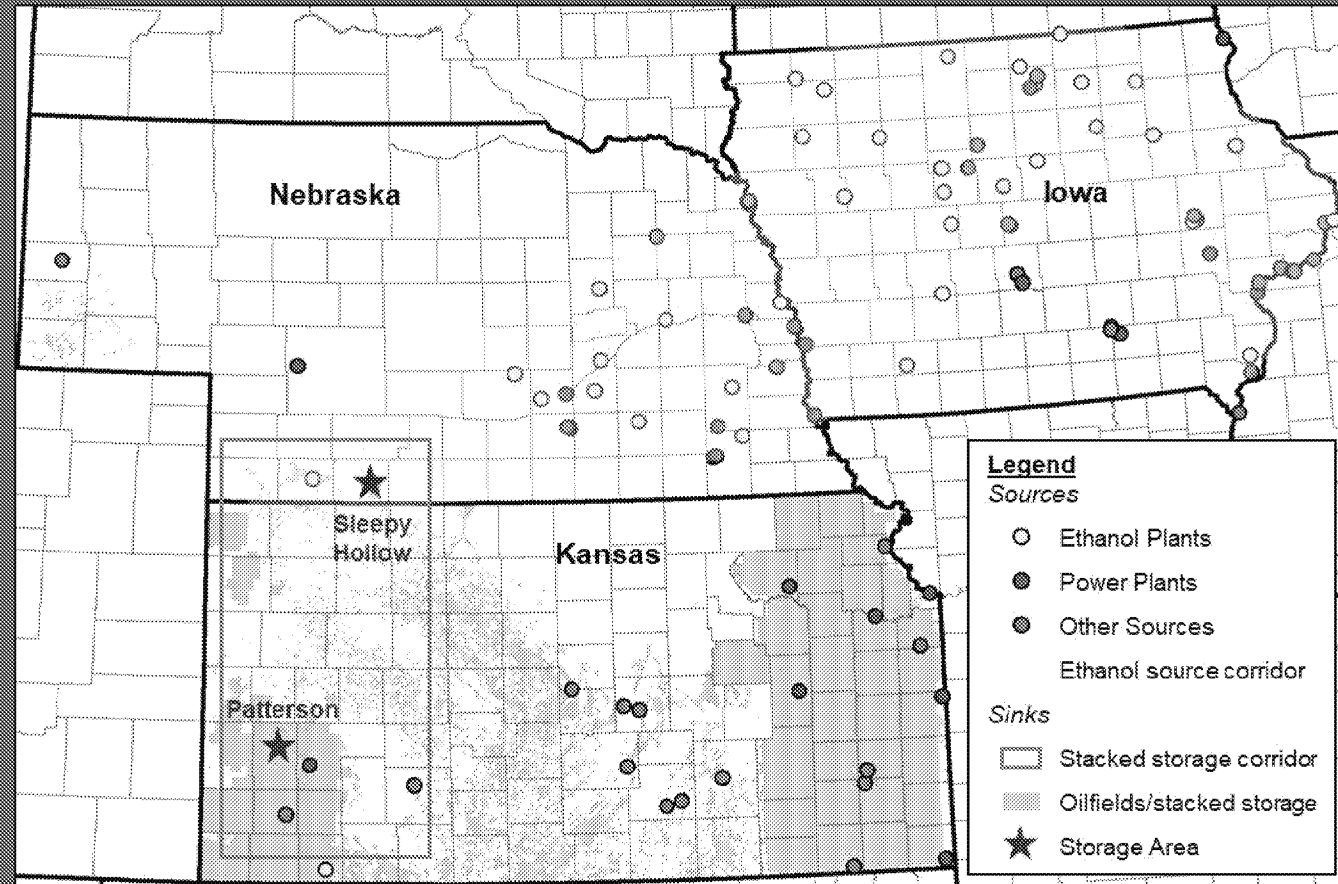
CARBON CAPTURE ECONOMICS

Andrew Duguid, Research Leader

Battelle



CCUS Economics



Andrew Duguid Ph.D., P.E.
Ben Grove

Battelle

July 21, 2020

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Outline

- Background
- Commercial Project Development Steps
- Economic Analysis Parts
- Assumptions and Required Information
- Capture,Transport, and Storage Economics
- CO_2 EOR
- Summary and Conclusions

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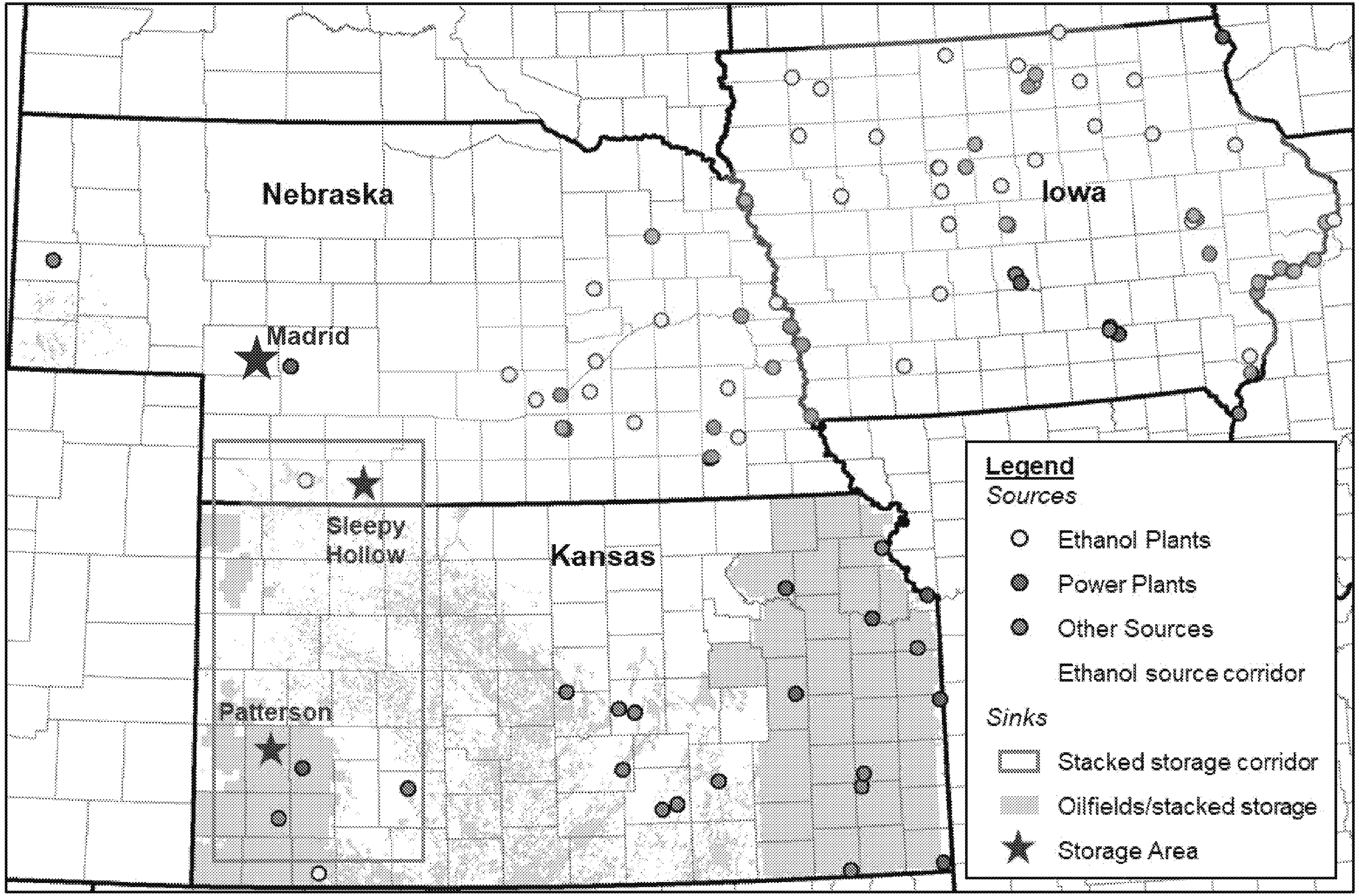
Project Area (From IMSCS-HUB Project)

- Sources in the area that may benefit from CCUS projects



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Roadmap to CCS

Phases	Phase I- Feasibility	Phase II- Assessment and Planning	Phase III- Site Characterization	Phase IV- Construction	Phase V- Operations and Maintenance
Timeline per site	3 months	3-6 months	1 year	2-3 years	12 years
Activities	Assessment of local geology Assessment of social factors Economic analysis	Conceptual Modeling and Simulation Gap Analysis and Data Collection Plan Permitting and regulatory plan Characterization plan	Well drilling, data collection, and analysis Baseline monitoring and MRV plan development Development of implementation plan for a CCS program	Capture facility construction Transportation construction Injection well(s) and monitoring well(s) construction Operations and maintenance plan	Ongoing operations and maintenance

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Parts of an Economic Analysis

- **Capture Costs**

Internal Capture Model

  - Source type
  - Source size

- **Transport Costs**

NETL Transport Cost Model

  - Transport Distance
  - Transport Volume
  - Transport Method

- **Storage Costs**

NETL Saline Storage Model

CO_2 Prophet

  - Mass/ Injection Rate
  - Depth
  - Thickness
  - Porosity
  - Permeability
  - Oil Properties

- **Revenue**
  - CO_2 Sales
  - Oil Revenue

- **Tax Credits and Offsets**
  - 45Q
  - CA LCFS
  - Others

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Typical Assumptions

- **Site Screening**
  3 Months (2020)
- **Site Selection & Char.**
  1 year (2020)
- **Permitting/Construction**
  3 years (2021-2023)
- **Operation**
  12 Years: (2024 – 2035)
  30 Years: (2024 – 2053)
- **Post-Injection Site Care, Closure**
  10 years (2036 – 2045 or 2054 - 2063)

Oil Price: \$30/Stock Tank Barrel (STB)

Annual CO_2 Capture: 90% annual plant emissions

Discount Rate: 12%
Constant 2019 USD

Electricity Cost:
\$0.07/kWh

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12 Years: Current length of 45Q Tax Credit
30 Years: Credit extended to length of common commercial operations

CO_2 BEP for Ethanol w/Pipeline Costs: Minimum price ethanol plant must charge for CO_2 to recoup capture, MRV + transport costs

CO_2 BEP for Ethanol w/out Pipeline Costs: Minimum price ethanol plant must charge for CO_2 to recoup capture and MRV costs

Feasible CO_2 Selling Price Criteria: EOR project NPV > 0, EOR IRR ≥ 15%, CO_2 BEP for ethanol < CO_2 BEP for EOR

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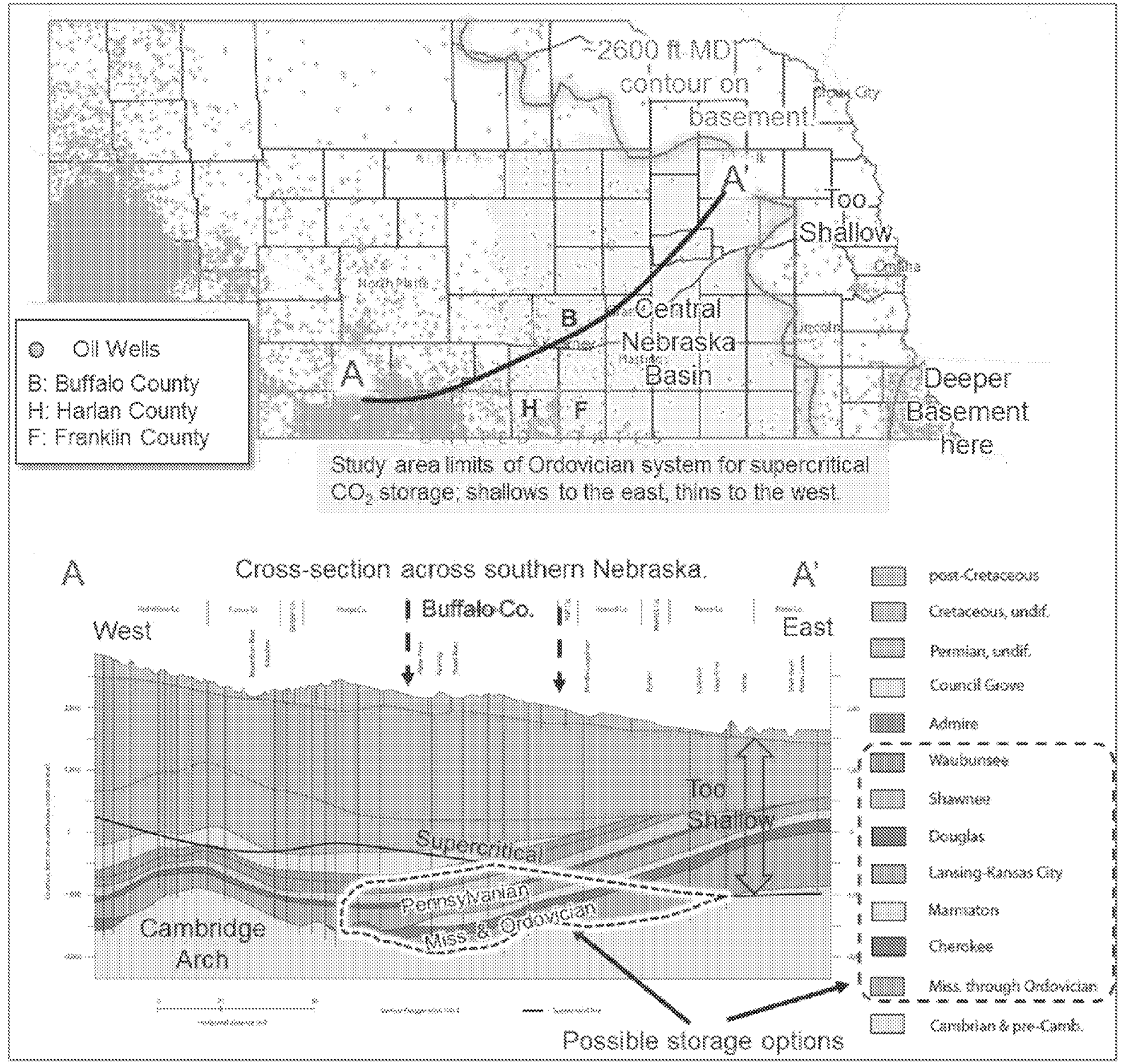
Potential Saline Reservoirs

- Storage available beneath the plant?
  - Geologic assessment
  - Caprock
  - Storage Unit(s)
  - Identify thickness, porosity, permeability
- Multiple stacked storage reservoirs present?
- Best potential saline storage close to the facility



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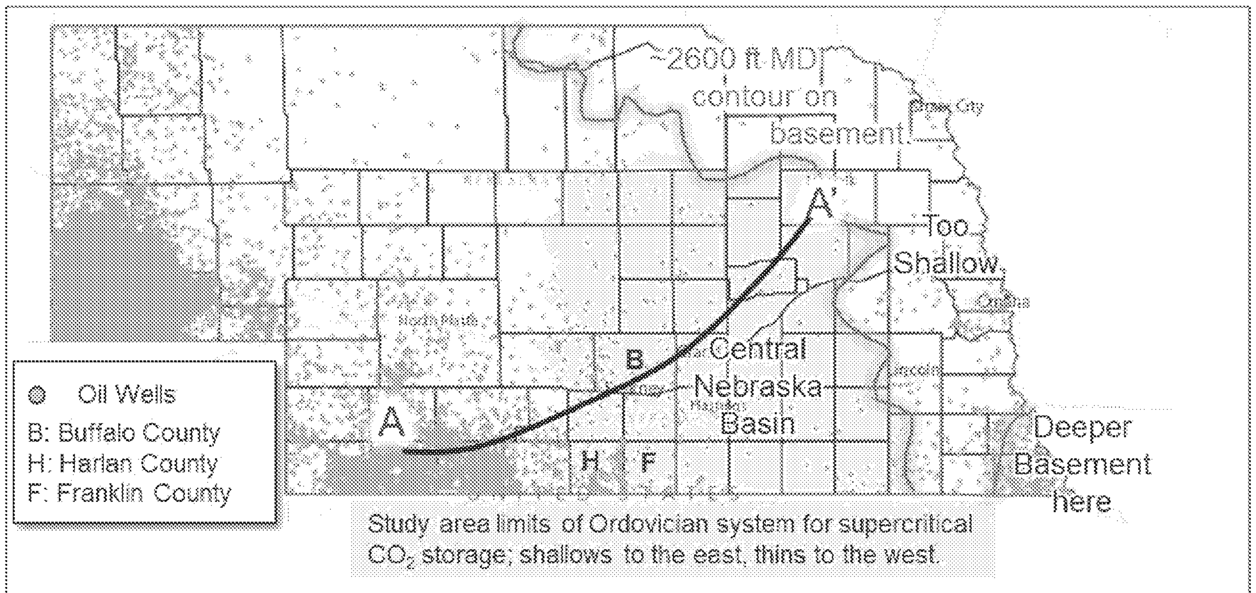
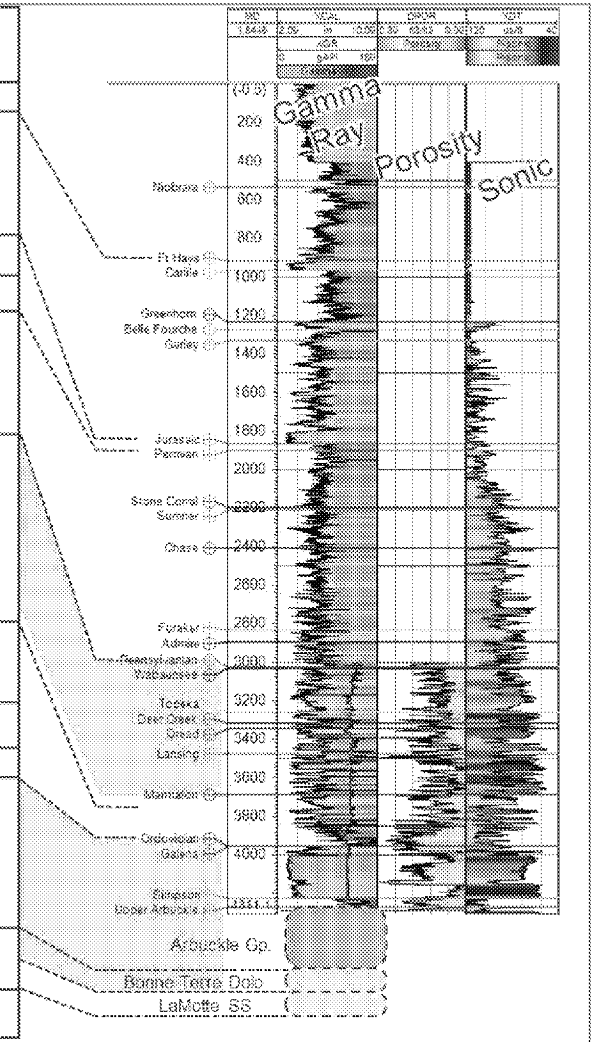
Site Screening

- Closest Well Logs
- Closest Existing Seismic
- Regional Geologic Information
- Estimate Missing Data



Age	Salina Basin NE – KS
Cenozoic	Ogallala Fm.
Cretaceous	Ft. Hayes Fm. Carlile Fm. Greenhorn Fm. Graneros Fm. Dakota Gp.
Jurassic	------- NA -------
Triassic	------- NA -------
Permian	Nippewalla Gp. Sumner Gp. Chase Gp. Council Grove Gp. Admire Gp.
Pennsylvanian	Wabaunsee Gp. Shawnee Gp. Douglas Gp. Lansing Gp. Kansas City Gp. Pleasanton Gp. Marmaton Gp. Cherokee Gp.
Mississippian	Keokuk Dolo. Burlington Dolo. Gilmore City LS
Devonian	Undifferentiated
Silurian	Hunton Gp.
Ordovician	Maquoketa Galena (Viola) Decorah Sh. Simpson Arbuckle Gp. Undiff.
Cambrian	Bonne Terre Dolo LaMotte SS
Precambrian	Basement



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CO_2 Capture

Ethanol Plant Sizes between 50 and 225 mgy

Total Costs range from ~ \$34 to \$202 million

\$10/tCO_2 - \$18/tCO_2

Estimated electricity demand included in the cost

Results (all costs reported in 2019 USD)		12-Year Project	30-Year Project
CO_2 Capture	Approx. Plant Size (million gal/y)	50-225	50-225
	Annual CO_2 Captured* (1000t)	155-730	155-730
	Years of Operation	12	30
	Total CO_2 captured (Million t)	1.87-8.76	4.68-21.90
	Capital Cost (Million \$)	8 – 23	7 – 23
	O&M Cost (\$)	26 - 81	65 - 202
	Total CO_2 Capture Cost (Million \$)	***34 - 104***	***73 – 225***
	Total CO_2 Capture Cost (\$/t)	***18 - 12***	***16 – 10***

*90% capture efficiency assumed

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CO_2 Storage

Results (2019 USD)		12-Year Project	30-Year Project
CO_2 Storage	Storage Zone	****	****
	Supercritical CO_2	yes	yes
	# of injection wells	1-2	1
	# of monitoring wells	2	2
	Required surface area (mi^2)	1-13	2.5-33
	CO_2 plume area (mi^2)	0.5-7.6	1.5-19
	CO_2 pressure plume Area (mi^2)	10-130	26-330
	Total CO_2 Stored (million t)	1.87-8.76	4.67-21.90
	Total 45Q Tax Credit (Million $)	***98 - 560***	***287 -1,640***
	Capital Cost (Million $)	13 - 23	19 - 50
	O&M Cost (Million $)	30 - 34	37 - 69
	Total CO_2 Storage Cost (Million $)	***33 - 57***	***56 - 119***
	Total CO_2 Storage Cost ($/t)	***18 - 6***	***12 - 5***

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LCFS Considerations

Annual net GHG reduction and CI reduction associated with a saline storage project are estimated following CARB protocol

Key Assumptions:

- CO_2 captured at 90% efficiency
- Estimated electricity demand
- Electricity emissions factor estimate
- Energy density of ethanol = 80.53 MJ/gal
- Negligible emissions due to direct land use change because project is on site
- No CO_2 emissions due to transportation
- CI Reduction between 25 and 30 points

GHG Reduction and CI Improvement	
CO_2 Injected (tonnes/day)	300-2000
CCS Project Emissions (tonnes/day)	35-200+
Net GHG Reduction (tonnes/day)	280-1,650+
Net GHG Reduction (tonnes/yr)	105,000-600,000+
CI reduction (gCO_2e/MJ)	25-30+
LCFS Credit Value ($/tonne)	~200
Annual LCFS Credit Value ($)	20,000,000-100,000,000+

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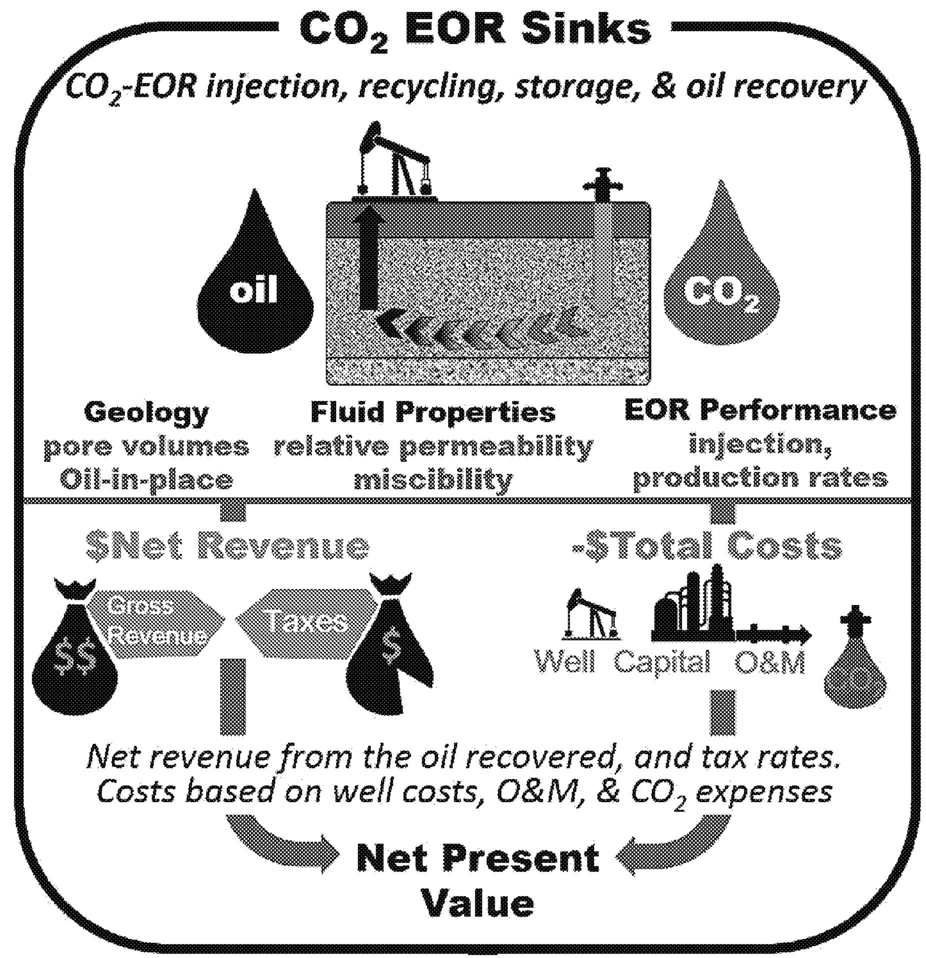
CO_2-EOR Considerations

- Number of Wells
  - Well Integrity
  - Conversion of existing wells
- Number of Leases
  - Unitization?
- Number of Operators
- Remaining Oil in Place
  - Will the field support a 12-year project
- Distance to Field From Source
  - Pipeline costs
- Oil Properties
- Existing Business Relationships / Industry Understanding



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CO_2 Enhanced Oil Recovery

CCUS Results (all costs reported in 2019 USD)		12-Year Project	30-Year Project
CO_2 Capture	Plant Size (million gal/yr)	50	50
	Annual CO_2 Captured (1000 t)	155	155
	Years of Operation	12	30
	Total CO_2 Captured (Million t)	1.87	4.68
	Capital Cost (Million $)	7.50	7.50
	O&M Cost (Million $)	26.3	65,7
	Total CO_2 Capture Cost ($/t)	**$18.03**	**$15.66**
CO_2 Transport	Pipeline Distance (mi)	2	2
	Pipeline Diameter (in)	4	4
	Years of Operation	12	30
	Capital Cost (Million $)	1.85	1.85
	O&M Cost (Million $)	1.11	2.77
	Total CO_2 Transport Cost ($/t)	***1.60***	***$1.00***
CO_2- EOR	Field	****	****
	Reservoir	****	****
	miscible?	yes	yes
	Pattern Life (yr)	50+	50+
	Total Patterns Available	25	25
	Field-Scale Net CO_2 Stored (Million tonnes)	1.18	1.65
	Net CO_2 Stored/CO_2 Captured (%)	65%	34%
	Field-Scale Total 45Q Tax Credit (Million $)	$42	$65
	CO_2 BEP for ethanol plant w/pipeline ($/t)	**$1.75**	**$4.00**
	CO_2 BEP for ethanol plant w/out pipeline ($/t)	**$(2.50)**	**$(2.00)**
Net Present Value of CCUS – Field Scale (Million $)[1,2]		7	6

[1]Assuming CO_2 selling price of $12.00 (40% of per barrel oil price) and cost of pipeline included
[2]Assuming an MRV cost of $4.18/tonne CO_2 stored

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Discussion

- Screening Study Needed
  - Need background information to estimate economics for storage and EOR

- Saline Project Storage Costs
  - Capture $18 - $12
  - Storage $18 - $6   (included short pipeline)
  - Total $36 - $18 – Significantly less that the ~$50/t 45Q tax credit
  - LCFS CI reduction provides significant additional incentive

- Capture for coal and gas fired electric utilities is just becoming commercial.   Costs are approximately $30 - $50/t. This means that some plants may break even with the 45Q tax credit. It also means that additional incentives are needed to get electric utilities to fully embrace CCUS.

Discussion

- EOR
  - Some projects have significant NPV
  - Uncertainty in oil markets and business relationships may have serious effect on project outcome
- CO_2-EOR will be new to the source
  - Need to feedback to meet MRV or ISO requirements to collect credits
- Easier permitting may provide no additional benefit if looking to meet LCFS
  - Need to build CA permenance assumption in the economic modeling from the beginning

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Thank You!

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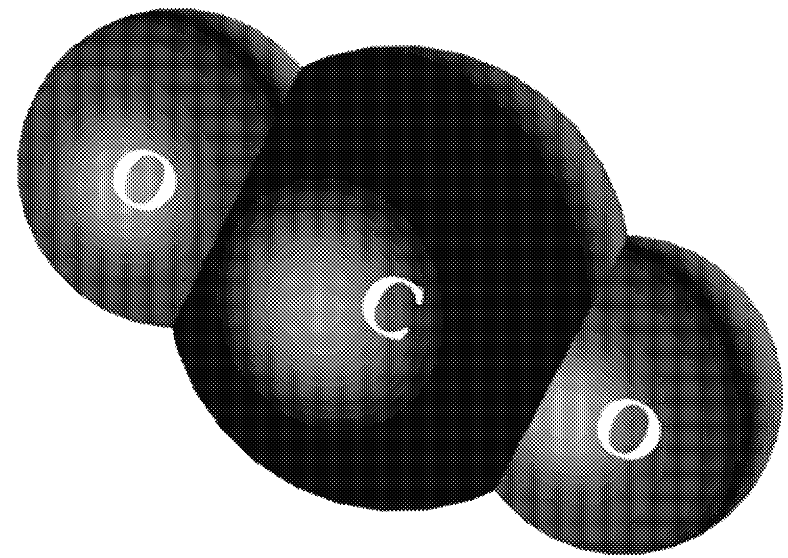
CARBON CAPTURE AT NEBRASKA PUBLIC POWER DISTRICT

John Swanson, Director of Generation Strategies and Research

Nebraska Public Power District

Nebraska Carbon Capture Webinar

Nebraska Public Power District (NPPD)



July 21, 2020
John Swanson
Director Generation Strategies and Research

Nebraska Public Power District
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Background

- CO_2 Reduction Initiatives at NPPD led by Generation Strategies Group
  - Need to know CO_2 Reduction potential impact costs
    - Inform Management and IRP
  - Desire to reduce our CO_2 footprint –
    - For ourselves and our customers
- NPPD has been engaged in CO_2 Reduction initiatives since 2012 with solvent testing at the Energy & Environmental Research Center (EERC) in Grand Forks, North Dakota
- CO_2 can be viewed as a commodity that should be managed from a statewide perspective
  - Ethanol and Power Plant CO_2 sources should achieve better economies of scale, e.g., a CO_2 collection pipeline would benefit all

Commercial Carbon Capture Design & Costing C3DC Phase 1

- Project Period of Performance:
  - May 30, 2018 – November 29, 2019
- Funding:
  - DOE-NETL $2,797,961
  - ION & Partners $ 699,500

DOE = Department of Energy
NETL = National Energy Technology Laboratory
ION = ION Clean Energy – Boulder, CO

Commercial Carbon Capture Design and Costing (C3DC) – Phase I

- DOE funded project focusing on an integrated design:
  - Retrofit / integrate a Carbon Capture System at a power station
  - Nebraska Public Power District's (NPPD) Gerald Gentleman Station (GGS) Unit 2
  - 300 MWe Slipstream for carbon capture (approximately 1.9 M tons)
- Project Team - NPPD, ION Clean Energy, Koch Modular, Sargent & Lundy
- Class 3 (AACE) Cost Estimate
  - -20% to +30%
- Project is complete – final report with DOE – not yet public
- $3.5M project budget

C3DC Phase 1 Study

Project Team and Roles

ION Clean Energy

- Technology Developer
- Process Design and Project Management

Nebraska Public Power District

- Host Site (GGS)
- Power Generation Engineering, Operational and Financial Expertise

Sargent and Lundy

- Engineering Firm that is familiar with GGS
- Participated in Petra Nova FEED
- All Balance of Plant Engineering

Koch Modular Process Systems

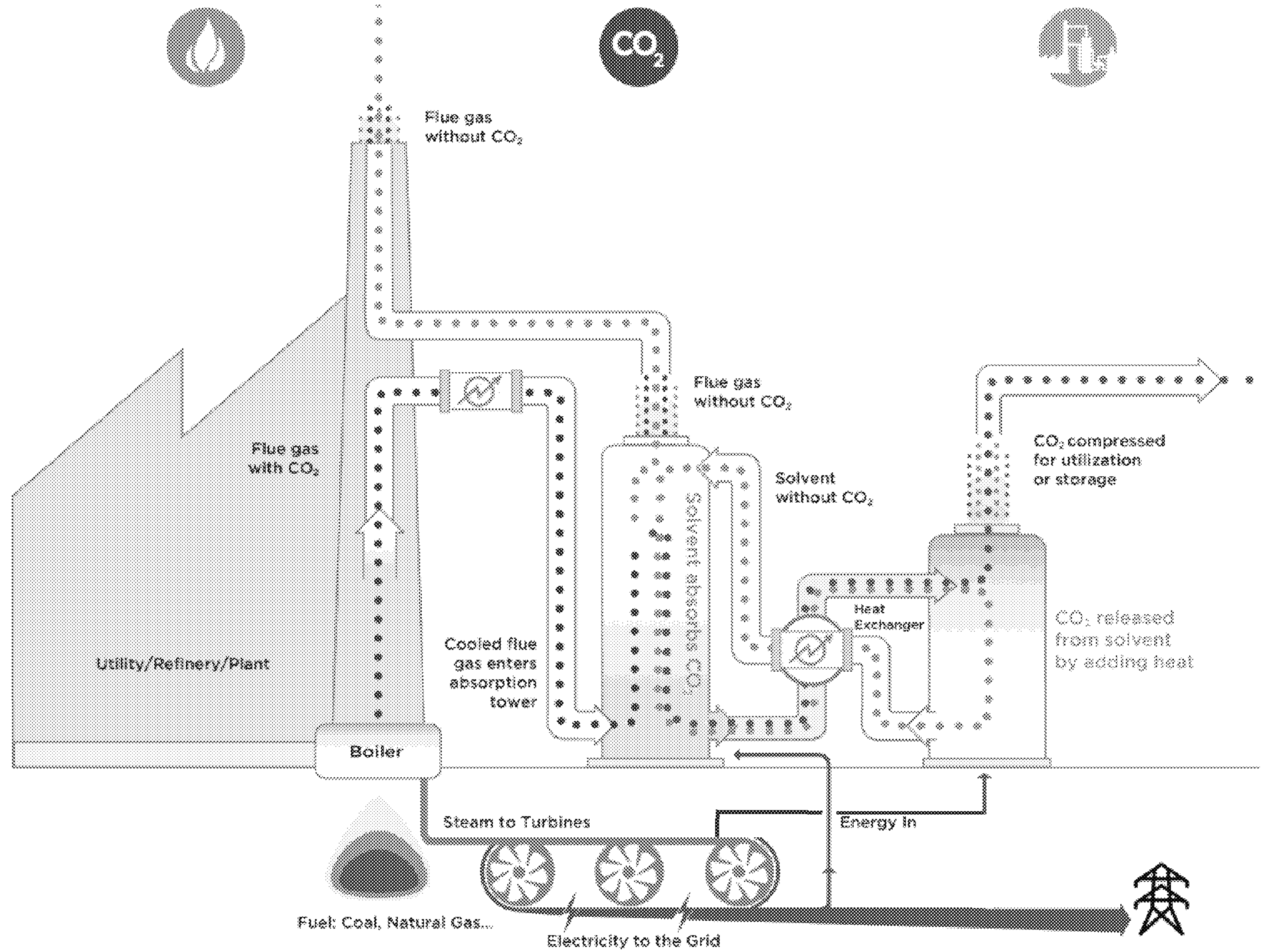
- Carbon Capture pilot experience and expertise
- Capture Process Oversight, Design and Costing

Siemens (Dresser-Rand / Ramgen)

- Compressor Vendor – Supersonic CO_2 Compressors

ION Technology Overview

- Proprietary Solvent-based Technology
  - Liquid absorbent-based capture
- Reduced CAPEX & OPEX
  - Smaller columns, HXs and footprint
  - Lower energy requirements
  - Lower emissions
  - Lower parasitic load
- Basis of Performance
  - Fast kinetics (on par or faster than MEA)



- MEA = Monoethanolamine

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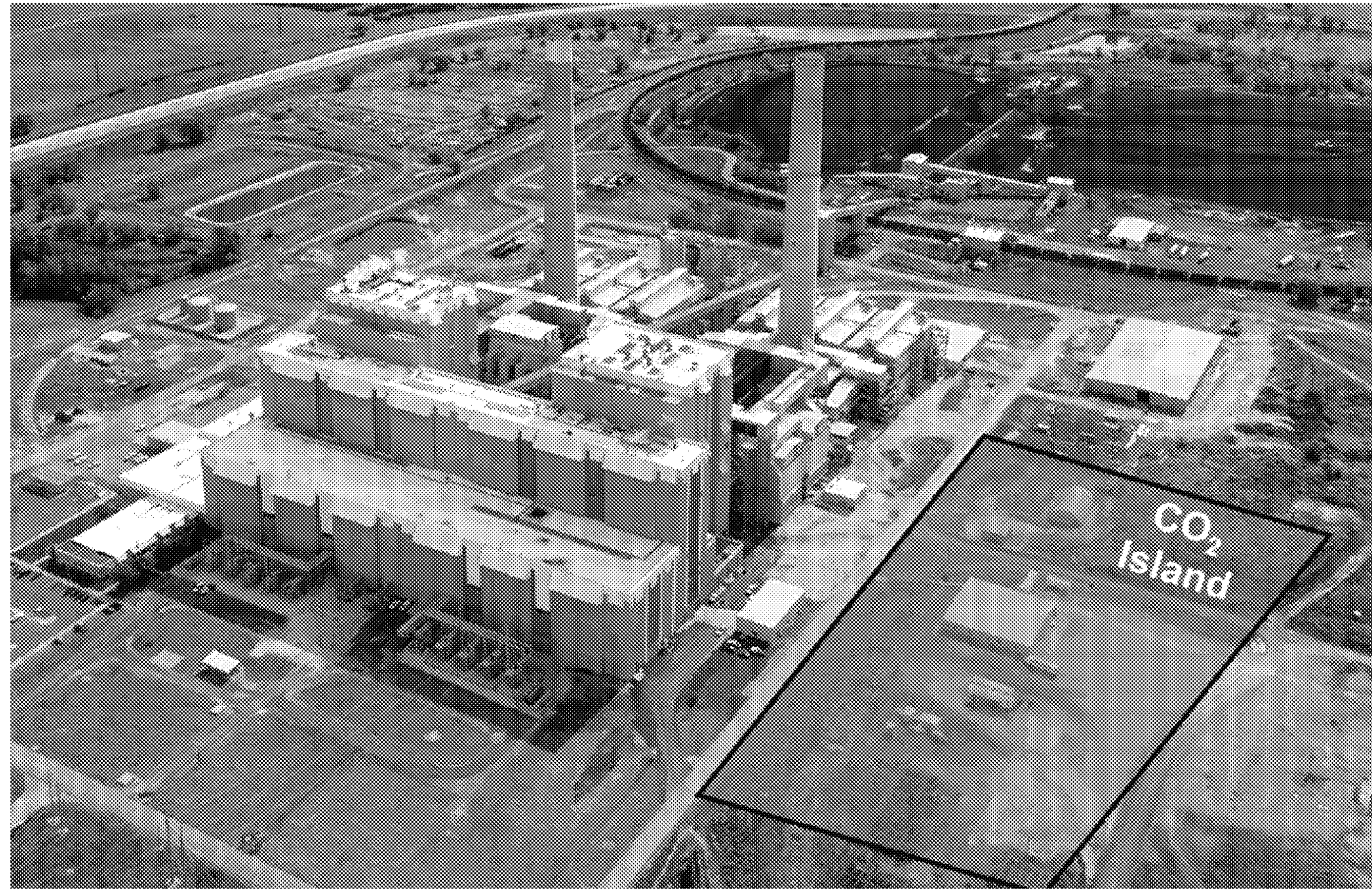
Nebraska Public Power District

Host Site – Gerald Gentleman Station

- Located in Sutherland, Nebraska
- Largest generating station in Nebraska
- Two units with total capacity of 1,365 MW
  - Unit 1 – 1979 – 665 MW
  - Unit 2 – 1982 – 700 MW
- Burns Powder River Basin Coal



Commercial Carbon Capture Design and Costing (C3DC2) – Phase II

- DOE funded project for 700 MW integrated design engineering effort building on results of C3DC Phase I
- Project Period of Performance: October 1, 2019 – March 31, 2021
- 90% CO2 capture of GGS2 flue stream
- Funding
    - DOE-NETL : $4.6M

C3DC2 Study

Project Team and Roles

ION Clean Energy
- Award Recipient
- Technology Developer
- Process Design and Project Management

Nebraska Public Power District
- Host Site (GGS)
- Power Generation Engineering, Operational and Financial Expertise

Sargent and Lundy
- World Renowned Engineering Firm
- Conducted the Petra Nova FEED
- All Balance of Plant Engineering
- Overall Cost Estimate Development

Koch Modular Process Systems
- Carbon Capture pilot experience and expertise
- Capture Process Oversight, Design and Costing

Siemens (Formerly Dresser-Rand / Ramgen)
- Compressor Technology Provider
- Supersonic CO_2 Compressor Design & Costing

Public Power – State of Nebraska

- Nebraska is the only all public power state
- Nebraska is a Dillon Rule state
  - Powers expressly granted by the state
  - LB 899
- NPPD cannot directly receive 45Q tax credits
  - Business relationship with those who can
    - EOR or CO_2 Sequestration options

Questions?

Nebraska Public Power District
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ETHANOL-BASED ECONOMIC CARBON CAPTURE

Keith Tracy, President

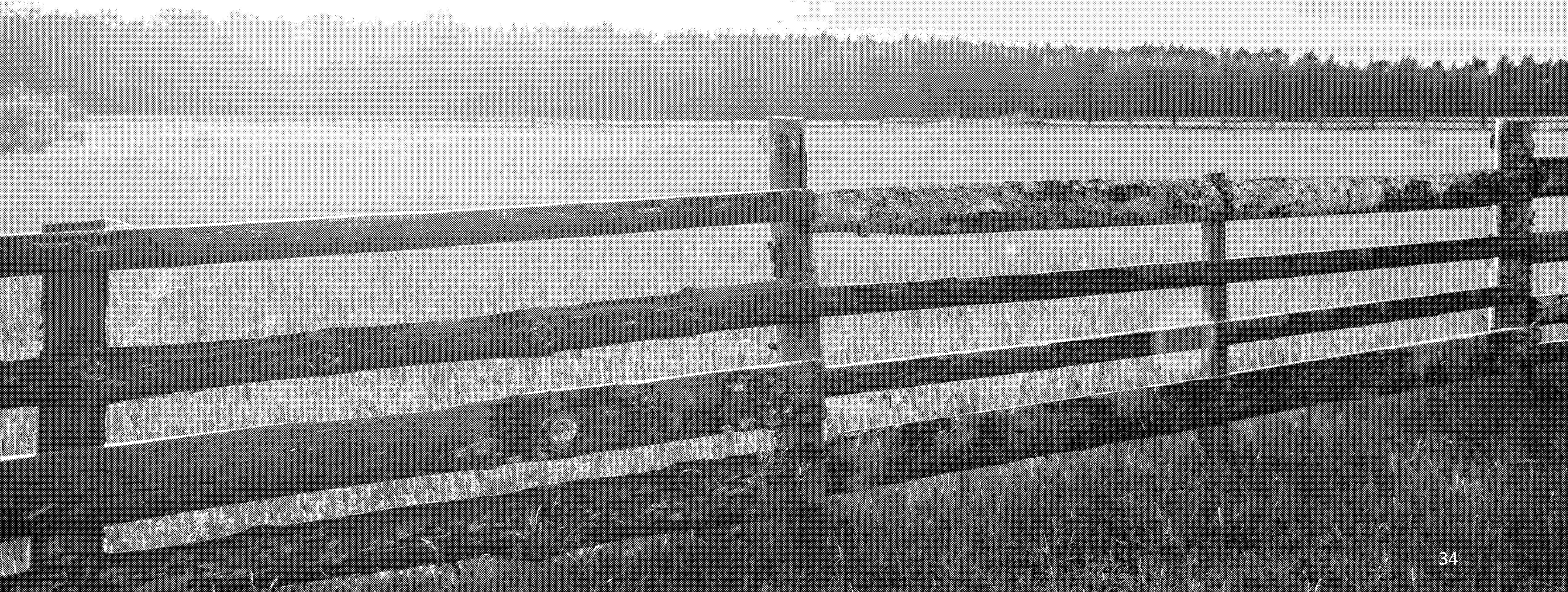
Cornerpost CO_2 Consulting

CornerPost
CO2 LLC

Ethanol-Based Economic Carbon Capture

Capturing Carbon in Nebraska—Webinar 2

July 21, 2020 | Keith Tracy



Cornerpost CO2 LLC

Carbon Capture Consultant

45Q Credit Expertise

Services:

- Comprehensive carbon capture consulting services
- Prepare and obtain EPA approval of Monitoring, Reporting and Verification (MRV) Plans under Subpart RR
- Advice regarding 45Q tax credit qualification
- Negotiate various CO2-related agreements (i.e. purchase and sale, pipeline transport, & sequestration)
- Provide recommendations to IRS for implementing 45Q
- Prepare and obtain approval of CO2 injection well permits for underground storage of CO2 in EOR or saline aquifers

Elysian Ventures LLC

Project Development Company

45Q Tax Equity

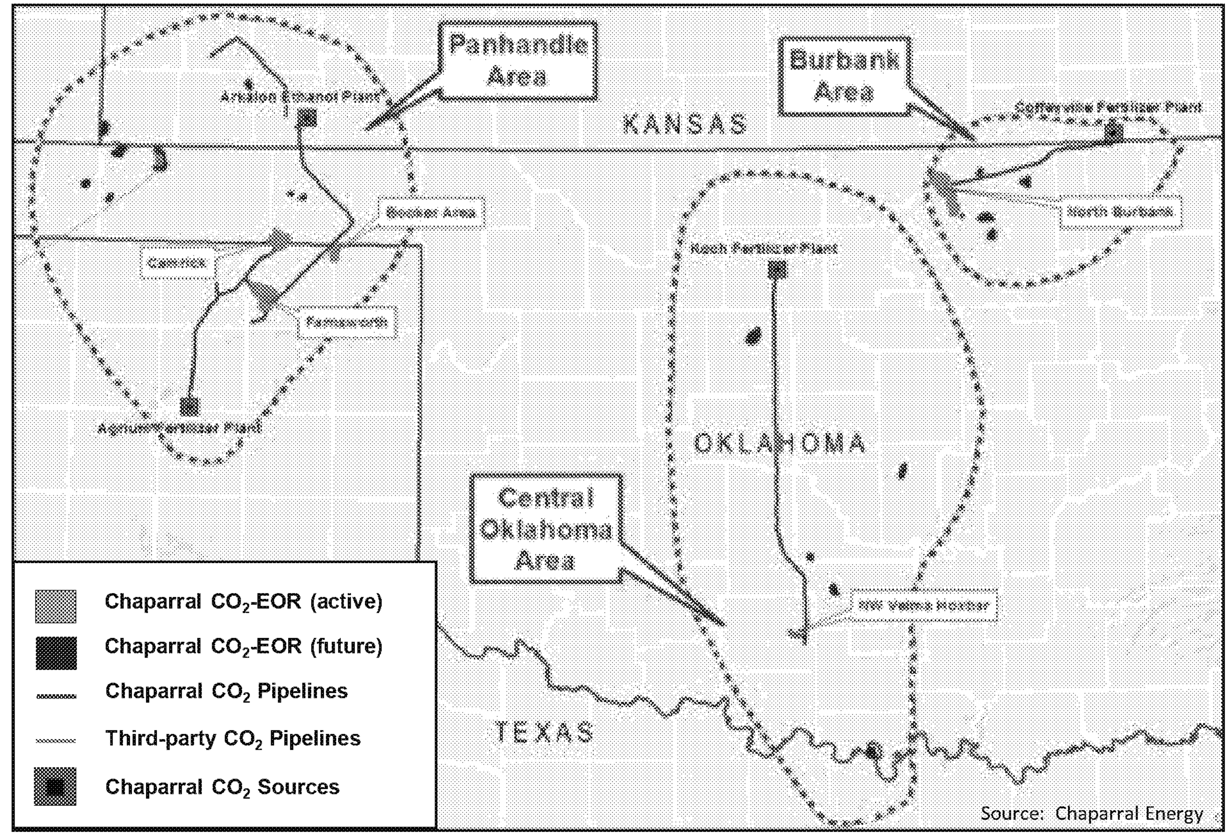
Services:

- Develop 45Q-based carbon capture projects
- Industries include ethanol, fertilizer, electricity (coal and natural gas), natural gas processing and other industrial facilities
- Develop a carbon capture project at a natural gas fired power plant Hired by Starwood Energy Group and the Oil and Gas Climate Initiative (OGCI) to
- Provide expertise on structuring tax equity partnerships

Experience

- Managed and directed operations of world's first carbon capture facility at an ethanol plant for purposes of geological storage
- Asset and operations team leader of Chaparral Energy CO_2 Midstream Assets
    - 3 carbon capture plants
    - 250 miles of CO_2 pipeline
    - Installed cost of $175 million
- Developer of CO_2 capture plant at a fertilizer plant, and 70-mile CO_2 pipeline
- Management member of CO_2-EOR division of oil company
- 14 years experience in carbon capture industry; 25 years total in energy industry
- Lead Instructor of full day seminar on "45Q and CO_2-EOR's Vital Role in Carbon Management"
- Private law firm experience and in-house legal counsel for CO_2-EOR company

Carbon Capture and Storage Experience



Arkalon Ethanol Plant

- Liberal, KS
- ICM 110mgy facility
- Installed 2008

CornerPost

Arkalon Carbon Capture Plant

- Ethanol Plant
  - Liberal, KS
  - ICM 110mgy facility (blue)
  - Installed 2008
  - Substation (purple)
- Carbon Capture Plant
  - Operational 2009
  - ~275,000 metric tons/year of CO_2
  - CO_2 plant footprint (red)
  - Collection pipe or feeder line (yellow)
  - Buried CO_2 Pipeline (green)
  - Used for enhanced oil recovery (EOR)

Bonanza Carbon Capture Plant

- Ethanol Plant
  - Garden City, KS
  - ICM 55mgy facility (blue)
  - Installed 2007
- Carbon Capture Plant
  - Operational 2012; ~135,000 metric tons/yr CO_2
  - CO_2 plant footprint (red)
  - Buried CO_2 Pipeline (green) to EOR

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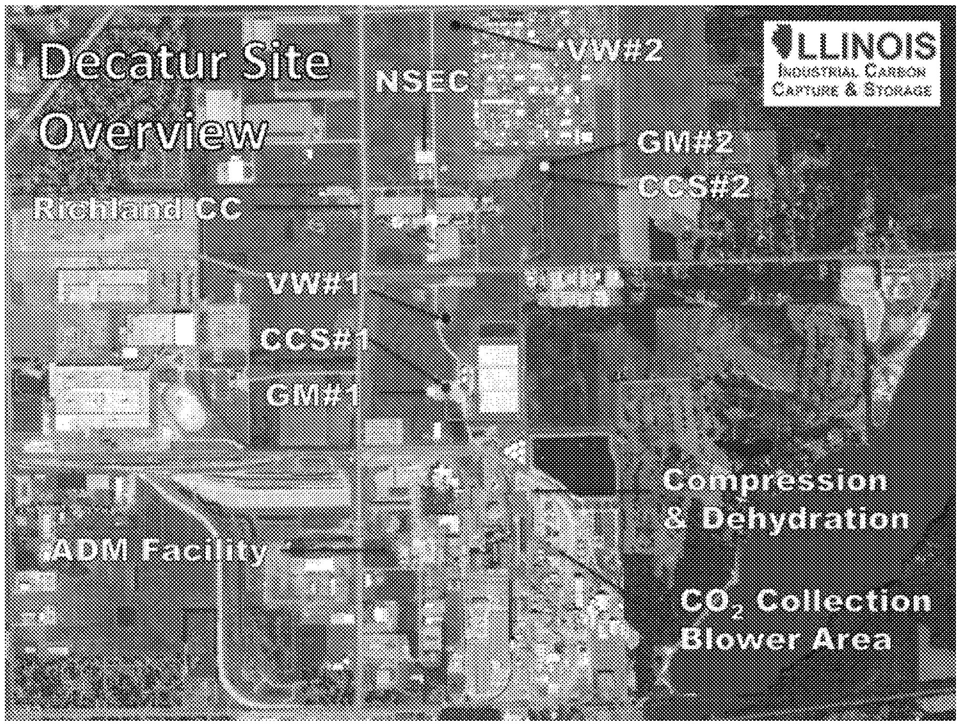
ADM-Decatur Carbon Capture Plant

- Operational 2012
- ~1,000,000 metric tons/year of CO2
- 1-mile CO2 Pipeline to Non-EOR
- Two Non-EOR injection wells
- Monitoring wells also required
- UIC Class VI permits

ADM-Decatur Site Overview



Source: ADM

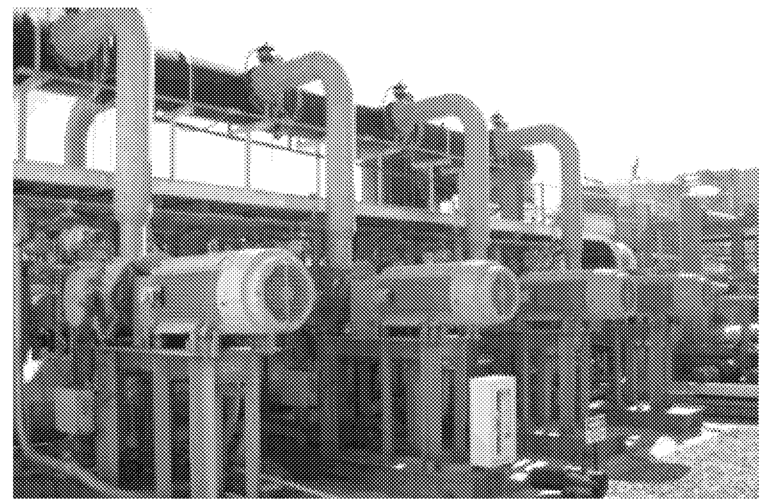
ADM-Decatur CO_2 Injection Well

Source: Herald & Review

Economic and operational considerations

- Timeline to build
- Proximity to ethanol plant
- Utilities and MCC building
- Compression and cooling
- Dehydration
- Pumping
- Design decisions
- Operations management
- Upsets/venting
- Maintenance and turnarounds
- Transport and storage obligations

CO_2 Compressors



CO2 Pipelines

- CO_2 is non-toxic, inert, colorless, odorless, non-flammable, very compressible, and slightly heavier than air
- High pressure CO_2 (1,200 – 3,000 psig) is compressed to a "supercritical fluid"

Outstanding CO2 Pipeline Safety Record

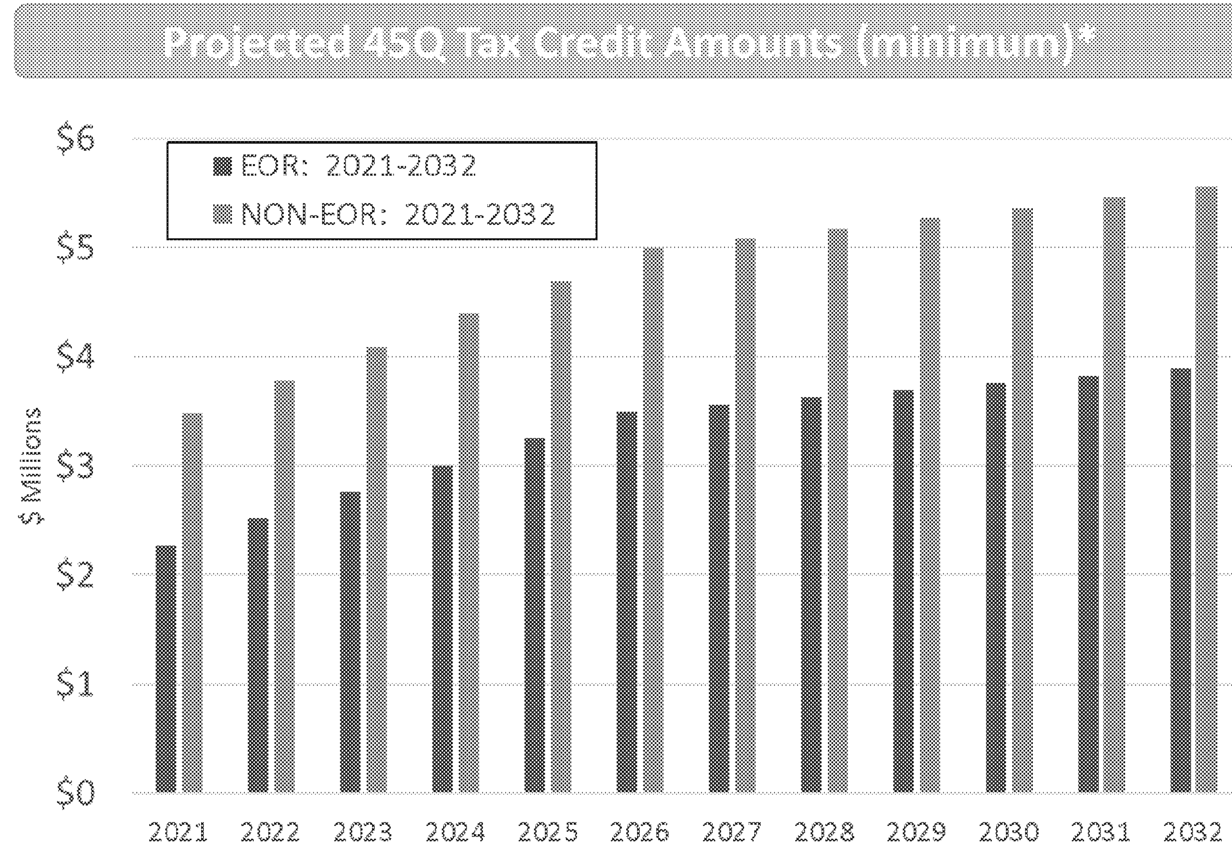
	CO2 Pipelines	Natural Gas and Liquids Pipelines
Leaks	26	5,983
Injuries	1	457
Fatalities	0	296

Source: CO2 Pipeline Transport Issues, SPE CCS Conference Nov 2009 (reviewing 1988-2008 data)

- Regulated by Pipeline Safety Act, and US Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Pipeline Safety (OPS), 49 CFR Part 195 regulations
- More CO_2 pipelines are needed
  - < 5,500 miles of CO_2 pipelines today in the US; EOR needs only required 100 miles/year (avg)
  - 25,000+ miles of CO_2 pipelines are needed to reach goals (estimates)

45Q tax credits are a significant financial incentive

- Section 45Q federal income tax credits for carbon capture and storage
- Activity tax credit for capturing CO_2 emissions from power plants or industrial sources, and utilizing it or injecting the CO_2 underground
  - Requires capture of at least 100,000 metric tons/year (500,000 for power plants)
  - Similar to wind/solar production tax credits (including tax equity structures)
- 12-year tax credit, starting on first injection
- Must begin construction by Jan 1, 2024
- Monitoring, reporting and verification (MRV) plan is required by EPA for non-EOR storage
  - Mass balance approach for counting net amount of CO_2 stored
- Minimum sized project will generate ~$40-60mm in tax credits over 12 years
  - Higher credit values are authorized if CO_2 is injected into saline aquifer

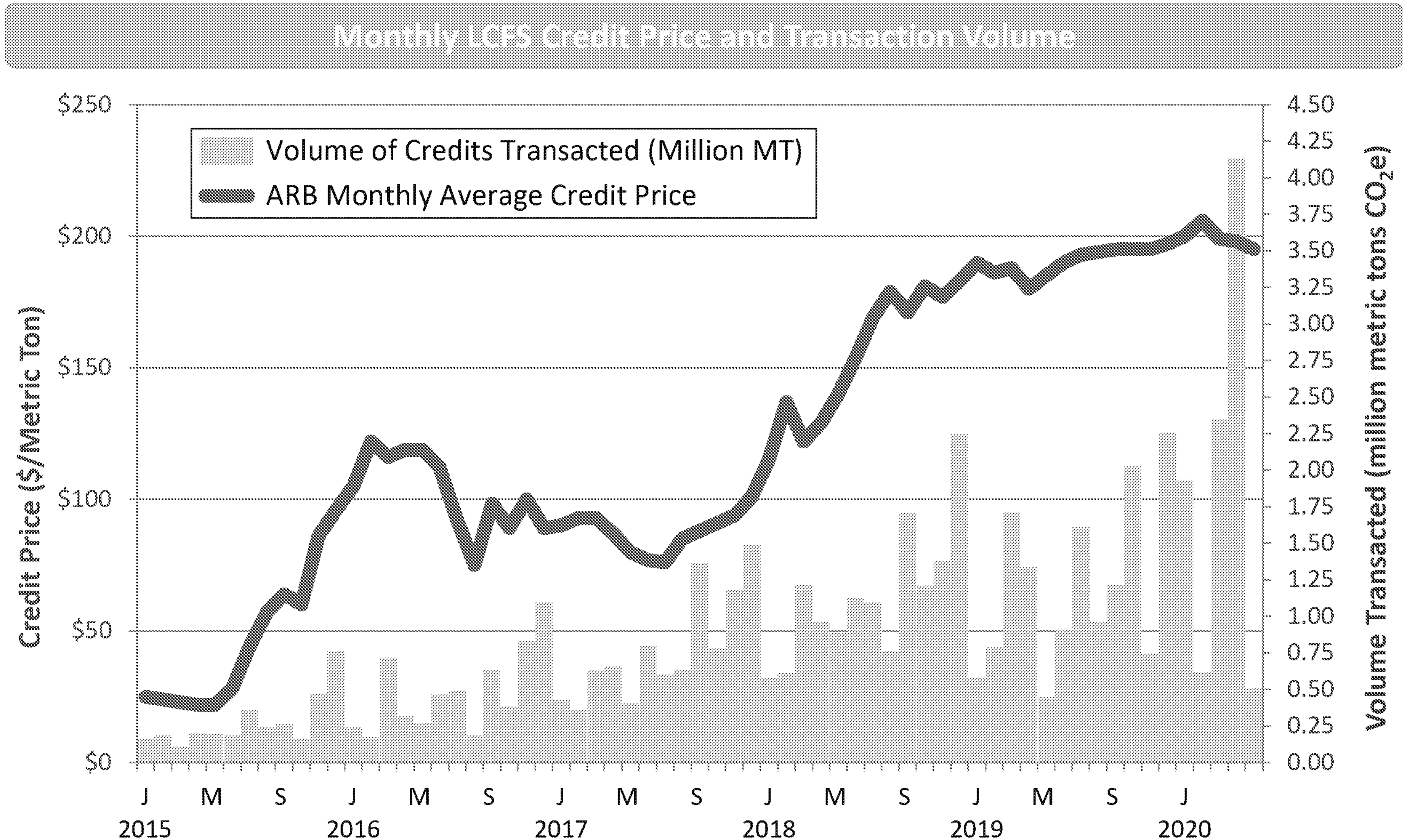


*Assumes 100,000 metric tons/yr, and 1.5% inflation rate after 2026

California LCFS (Low Carbon Fuel Standard)

- Carbon Capture and Sequestration (CCS) Protocol
  - Adopted effective 1/1/2019

- Capturing CO2 from ethanol plants provides additional incentive for ethanol sold in California



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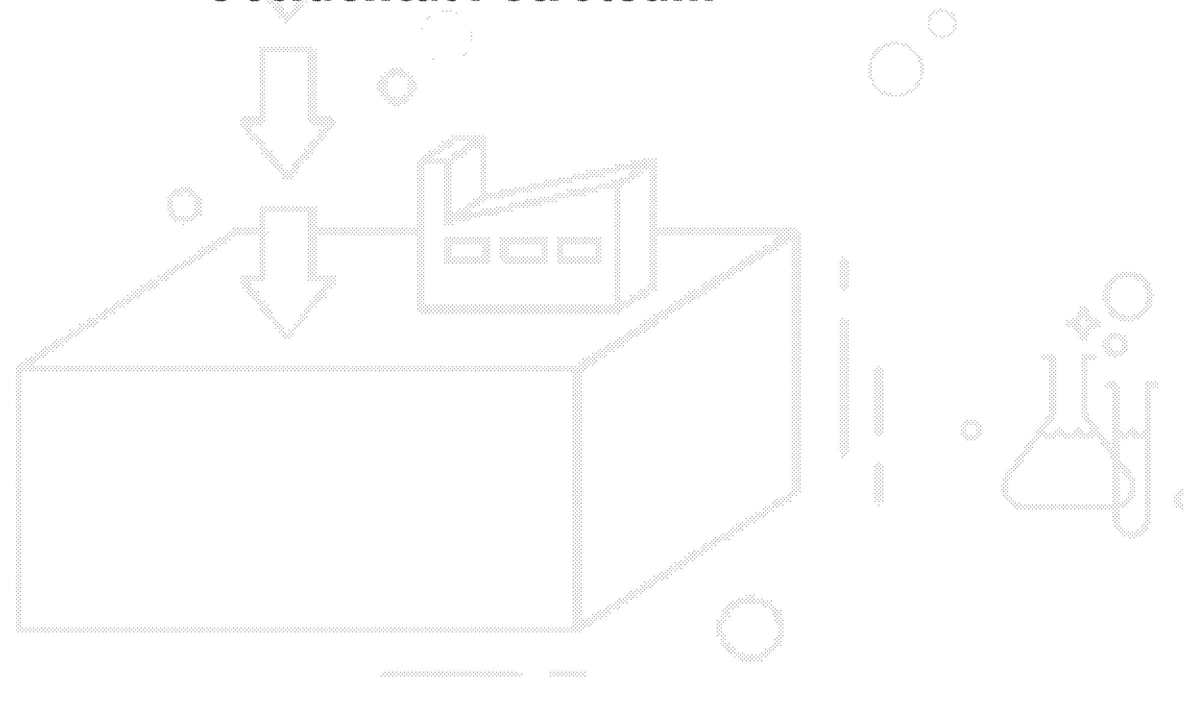
Conclusions

- Carbon capture at ethanol plants has been demonstrated at commercial scale, and are operational today in the geographic region
- Geologic storage and CO2 pipeline distances need to be considered
- Business partners stand ready to develop and finance carbon capture facilities at ethanol plants
  - Proper design and planning can reduce capital and operational expenses for carbon capture facilities
  - Critical path for timeline can be permits for injection wells, or time to permit and build pipelines
- 45Q tax credits are available for carbon capture facilities at larger ethanol plants
  - Tax equity structures and other planning should be considered early in the project
  - Approval of storage site monitoring plans will be required

CO_2 TRANSPORT AND SEQUESTRATION INFRASTRUCTURE

Ryan Edwards, Low Carbon Policy Advisor

Occidental Petroleum



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CO_2 Transport and Storage Infrastructure: Economics and Policy

Ryan Edwards
Low Carbon Policy Advisor
July 21, 2020

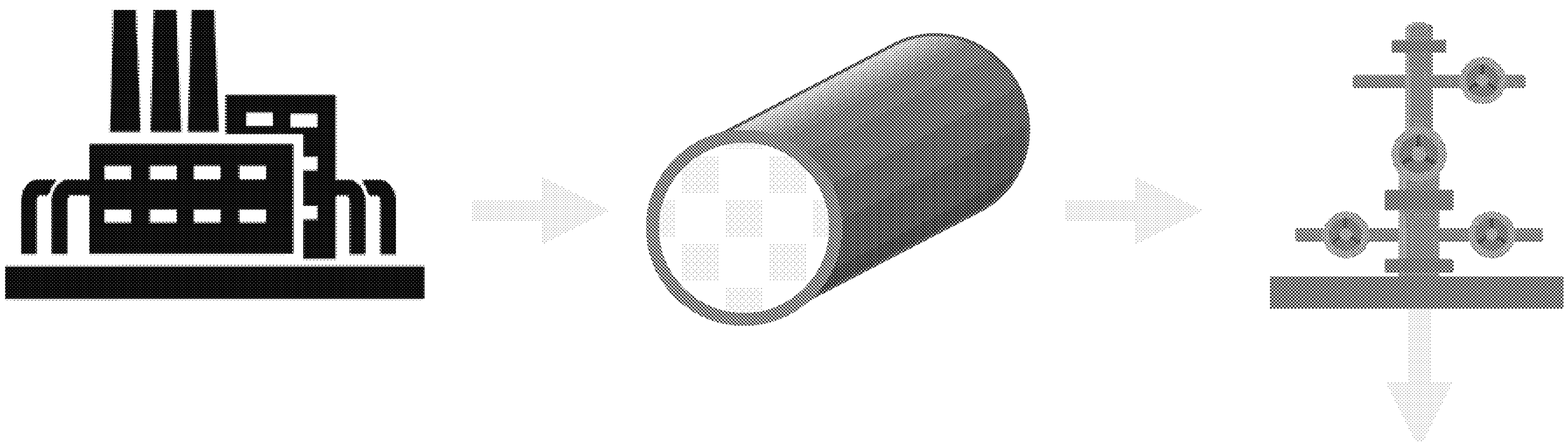
Ryan_Edwards@oxy.com

The Carbon Capture, Utilization, and Storage System

CO_2 Capture
(Industrial or Atmospheric)

Transport

Storage
(or Utilization)



Existing CO_2 Pipelines – 5,000 miles

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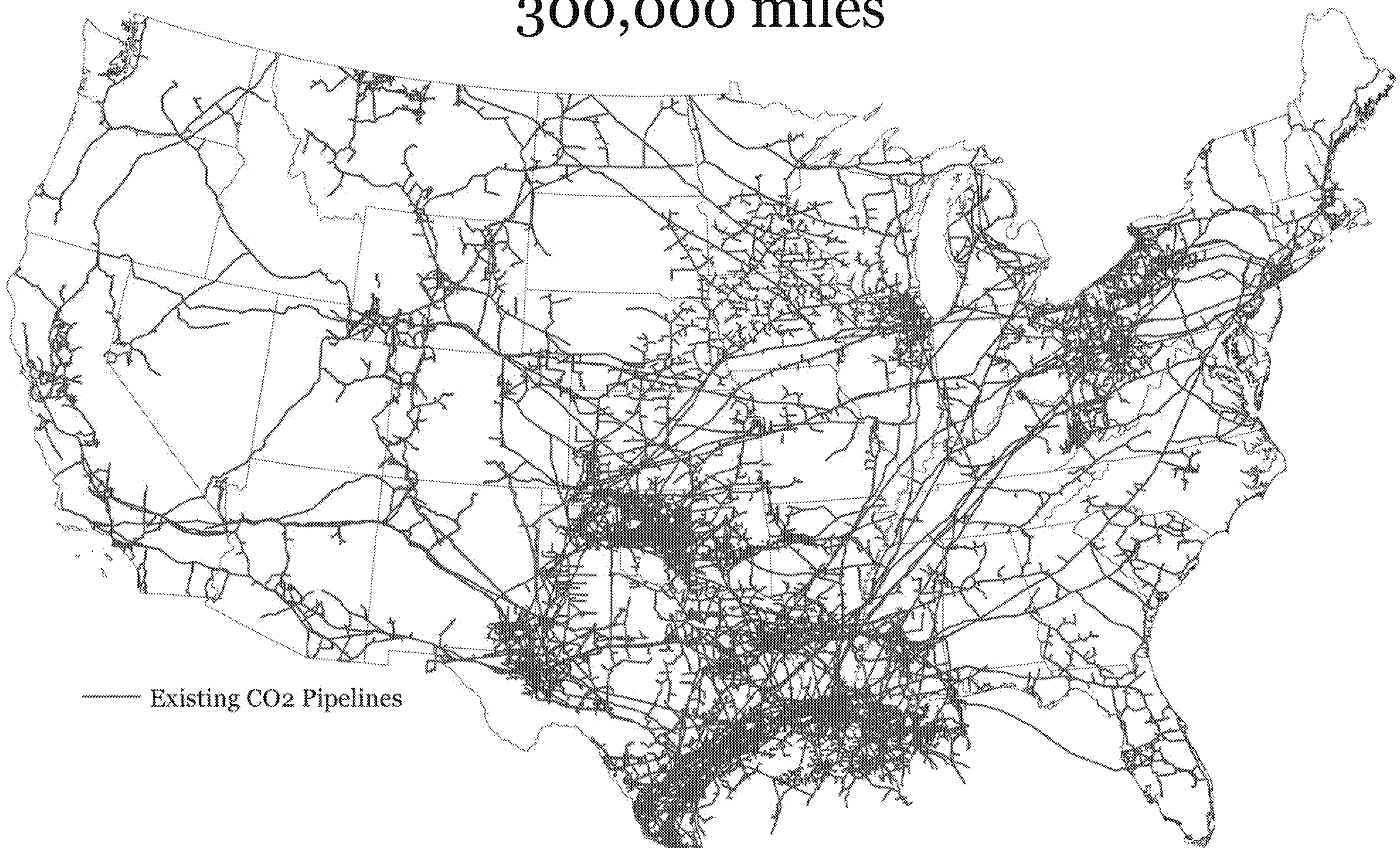
(Existing Natural Gas Interstate Pipelines)

300,000 miles



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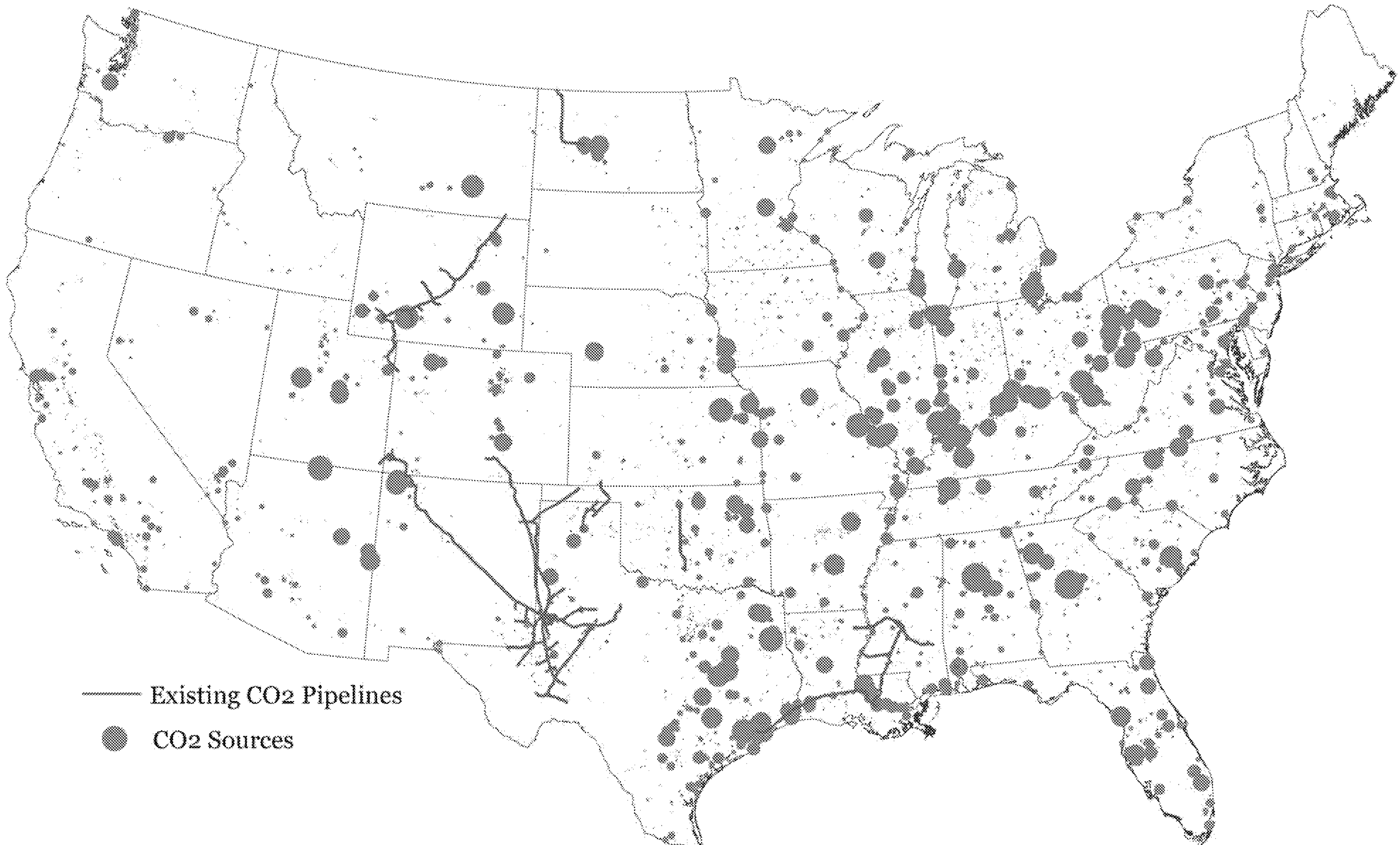
CO_2 Sources



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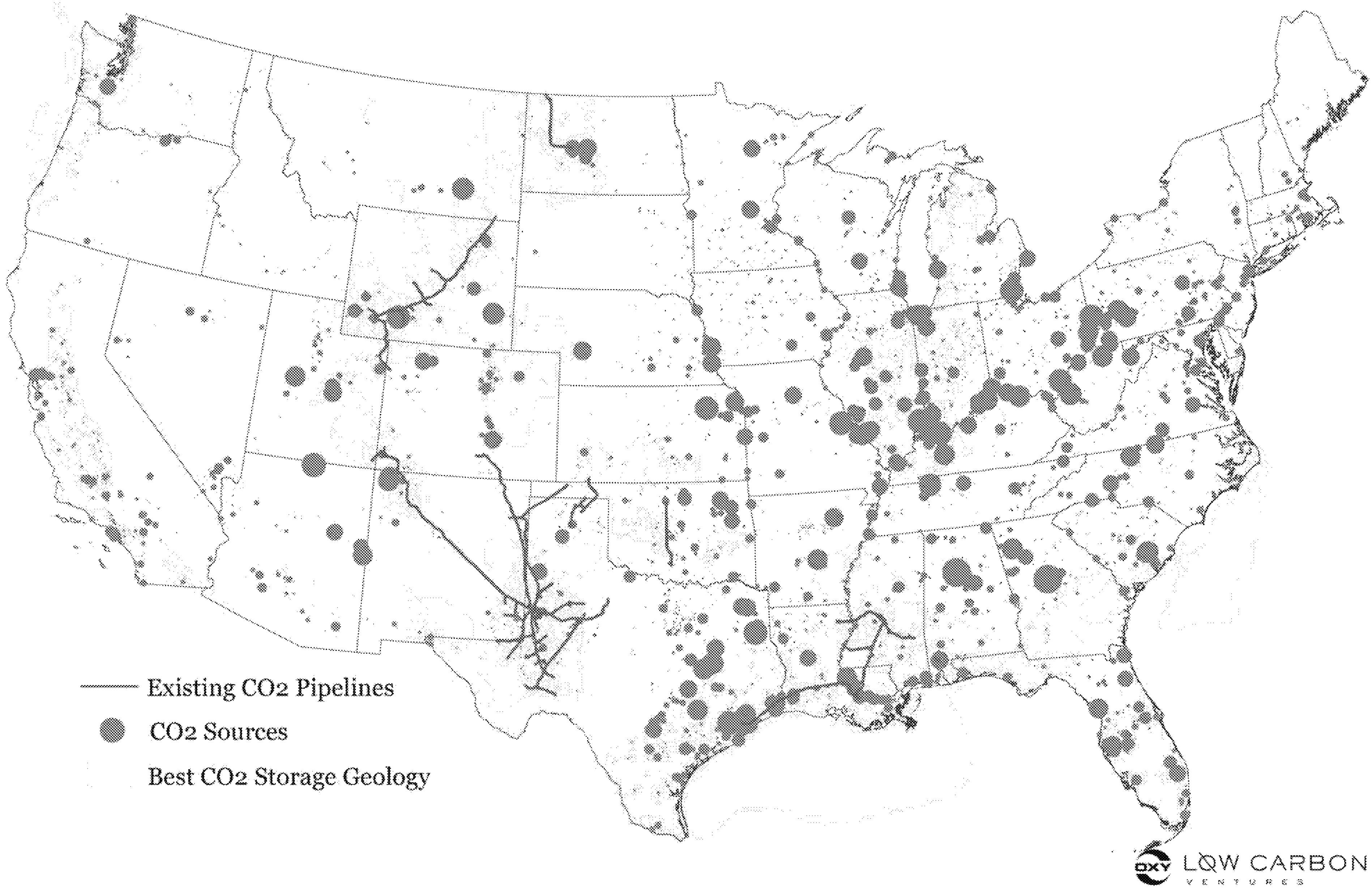
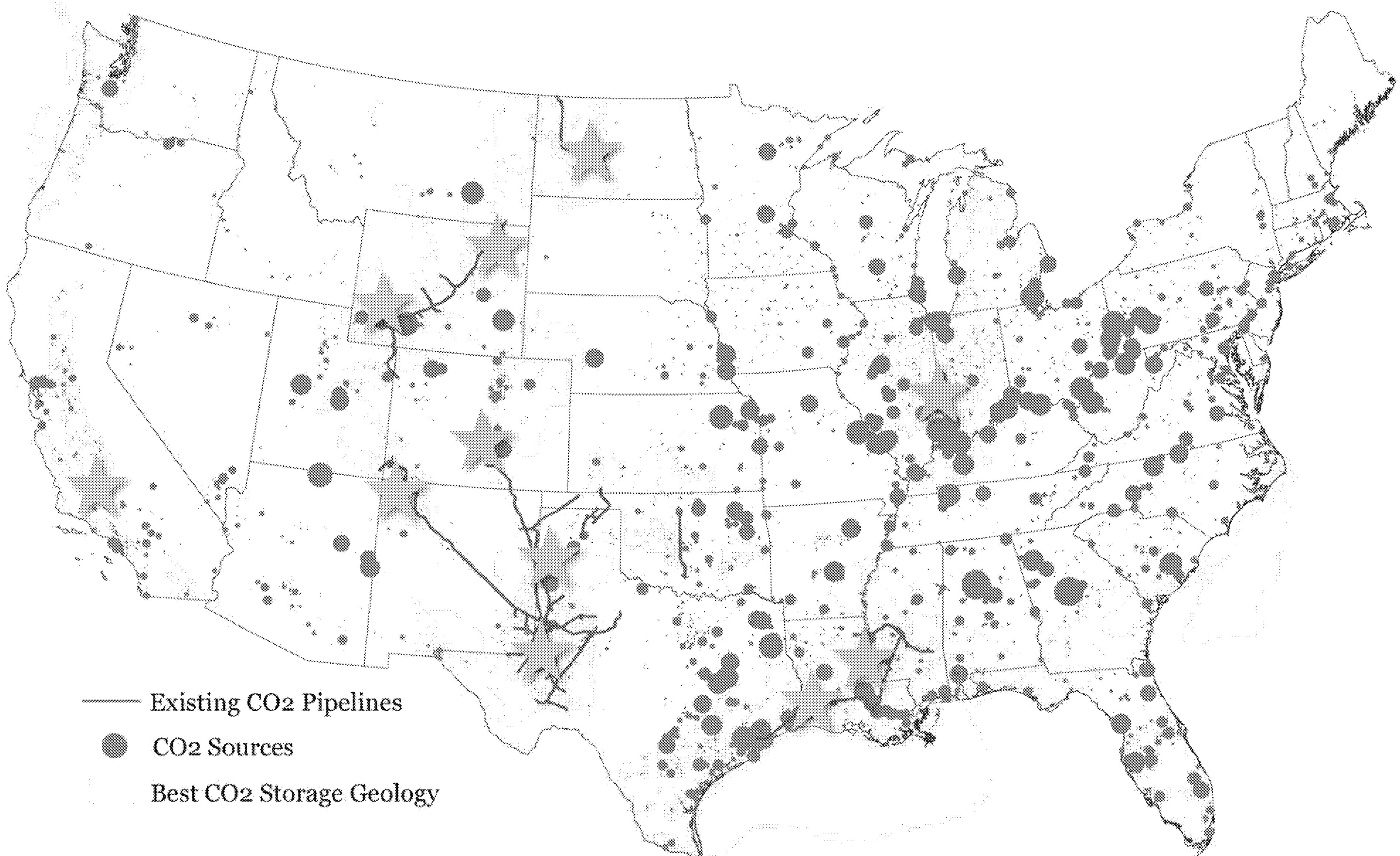
Best CO_2 Storage Geology



Announced Potential 45Q Projects



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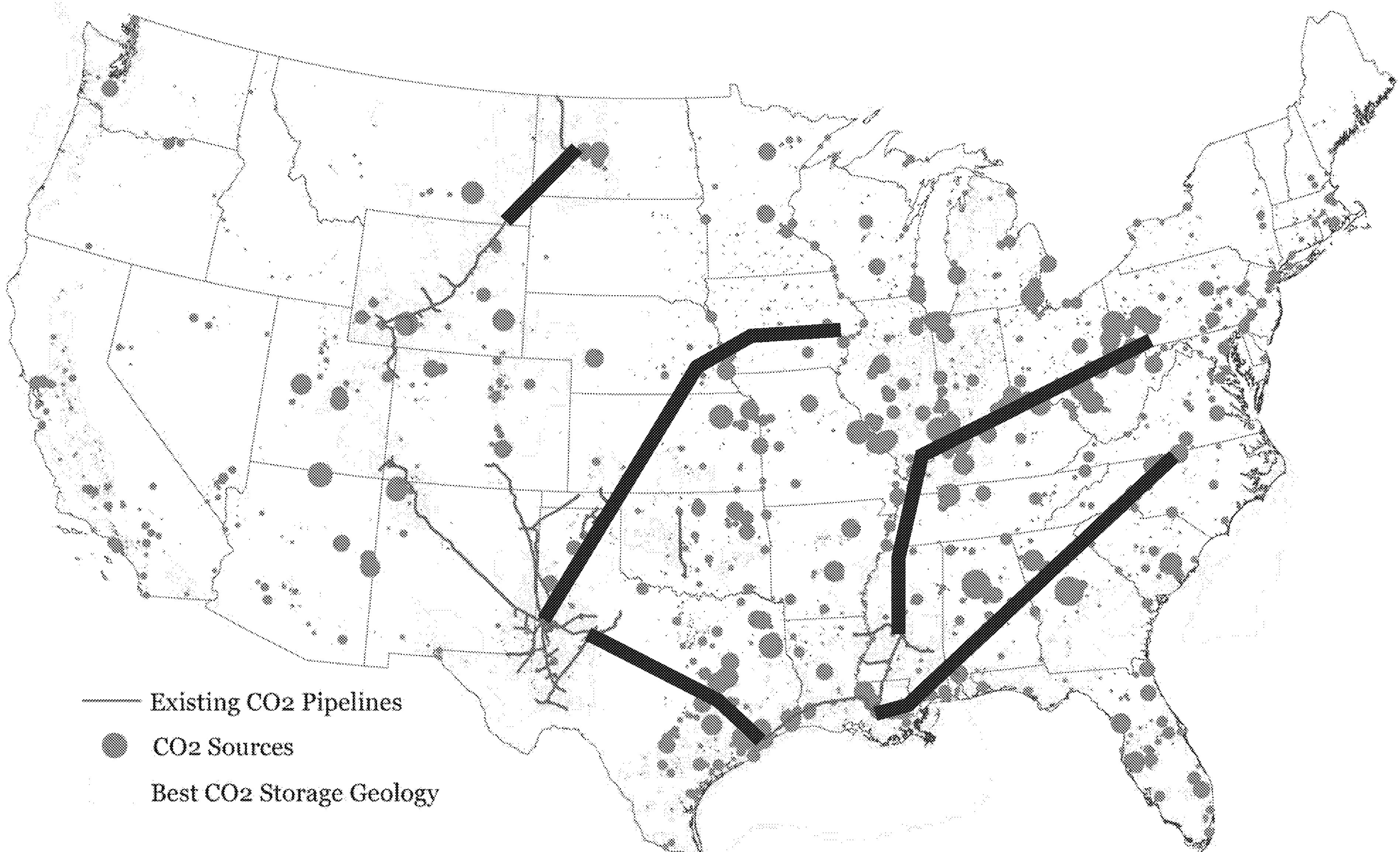
Potential Interstate CO_2 Trunk Pipelines



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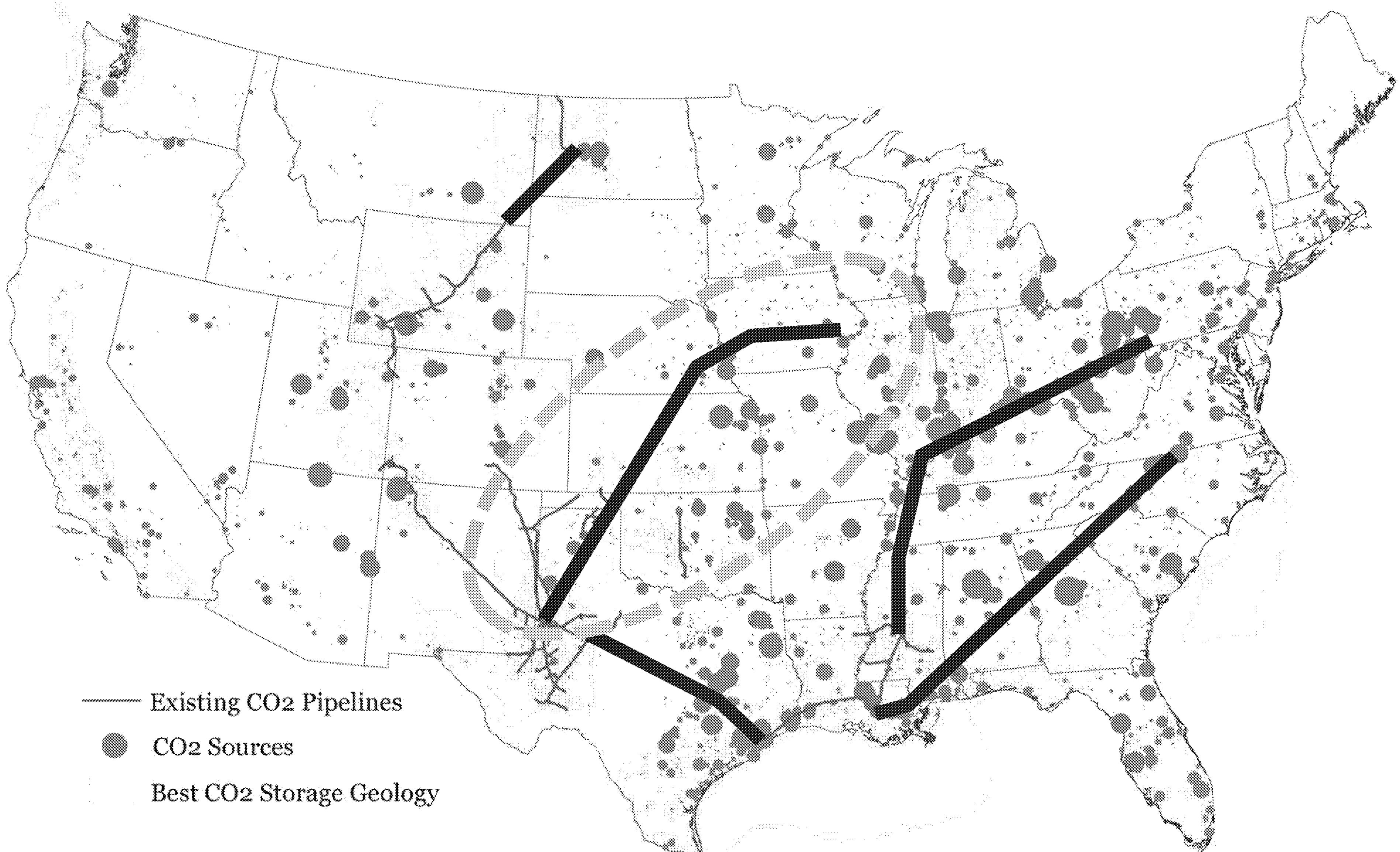
Midwest CO_2 Superhighway



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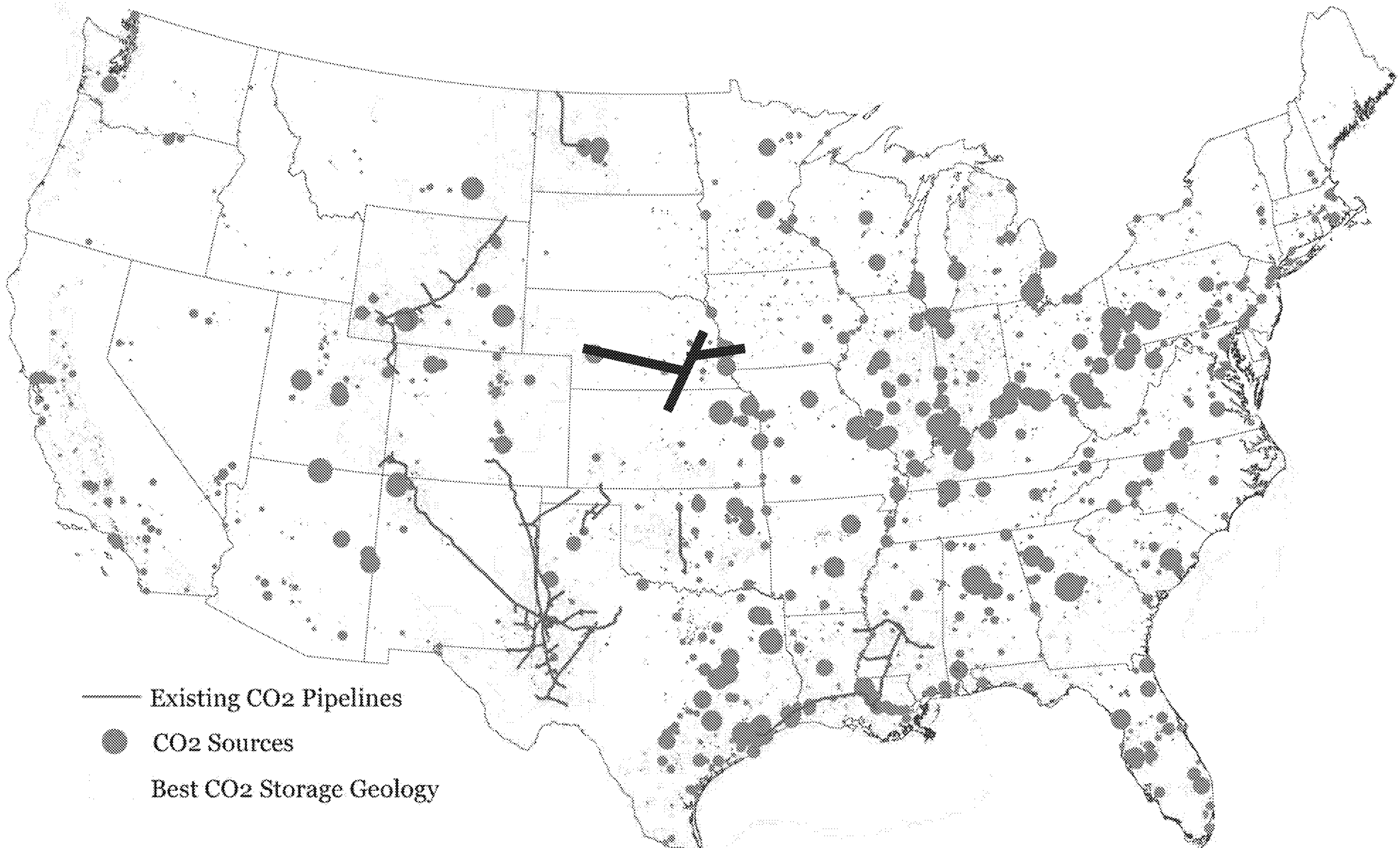
Regional Hubs



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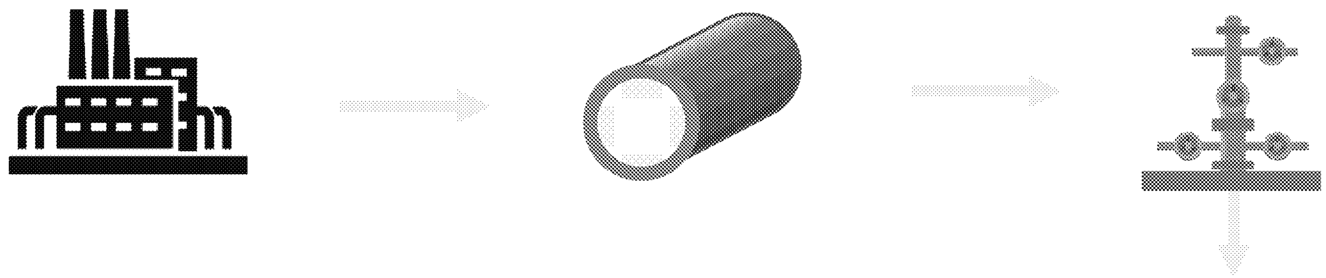
CCUS System Economics

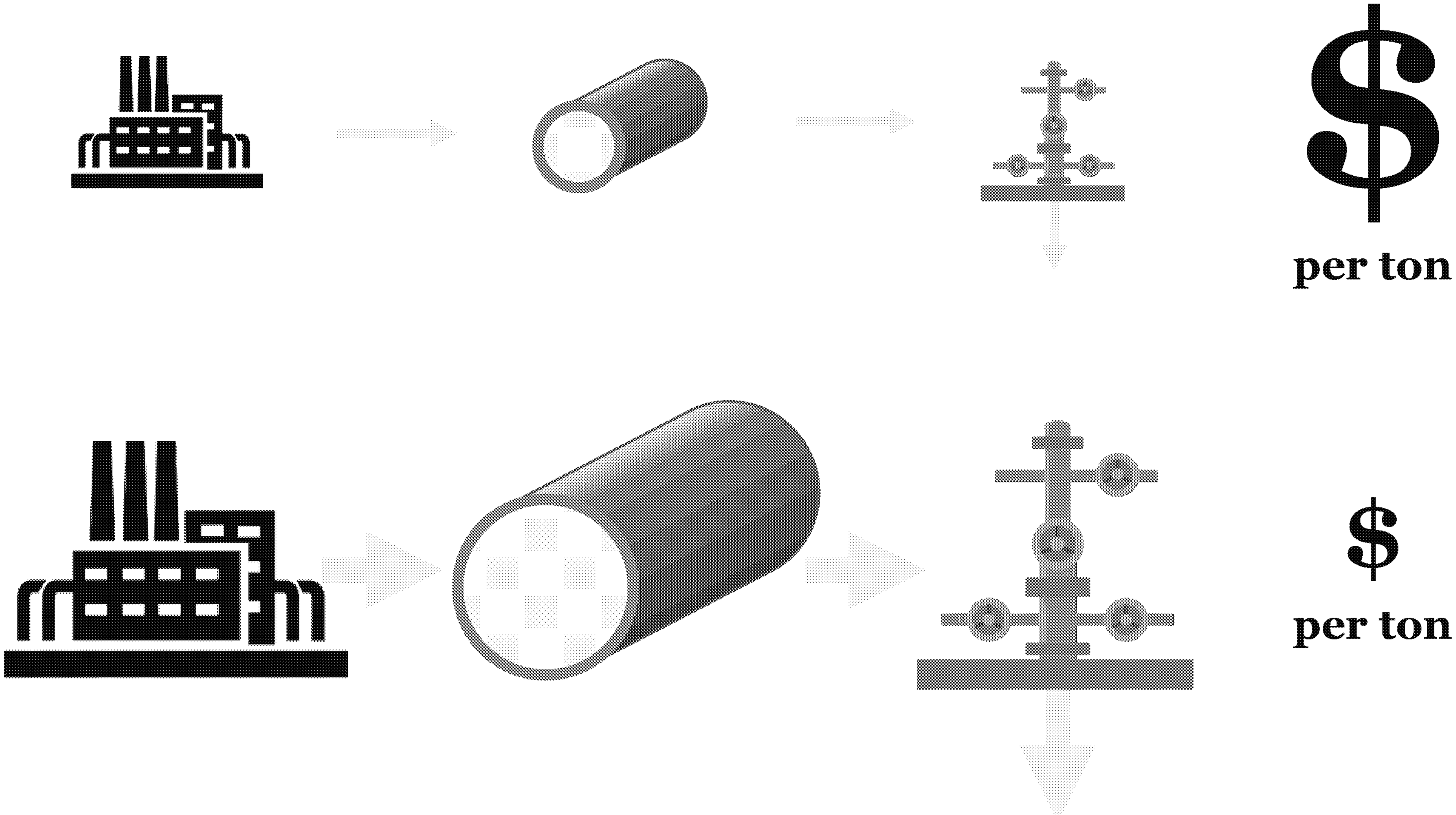


$

per ton

OXY LOW CARBON VENTURES

CCUS System Economics: Economy of Scale



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The Importance of CO_2 Transport Infrastructure

1. Enable capture of more CO_2 from more regions
2. Realizing economies of scale
3. Connectivity—creating a market, lowering risk

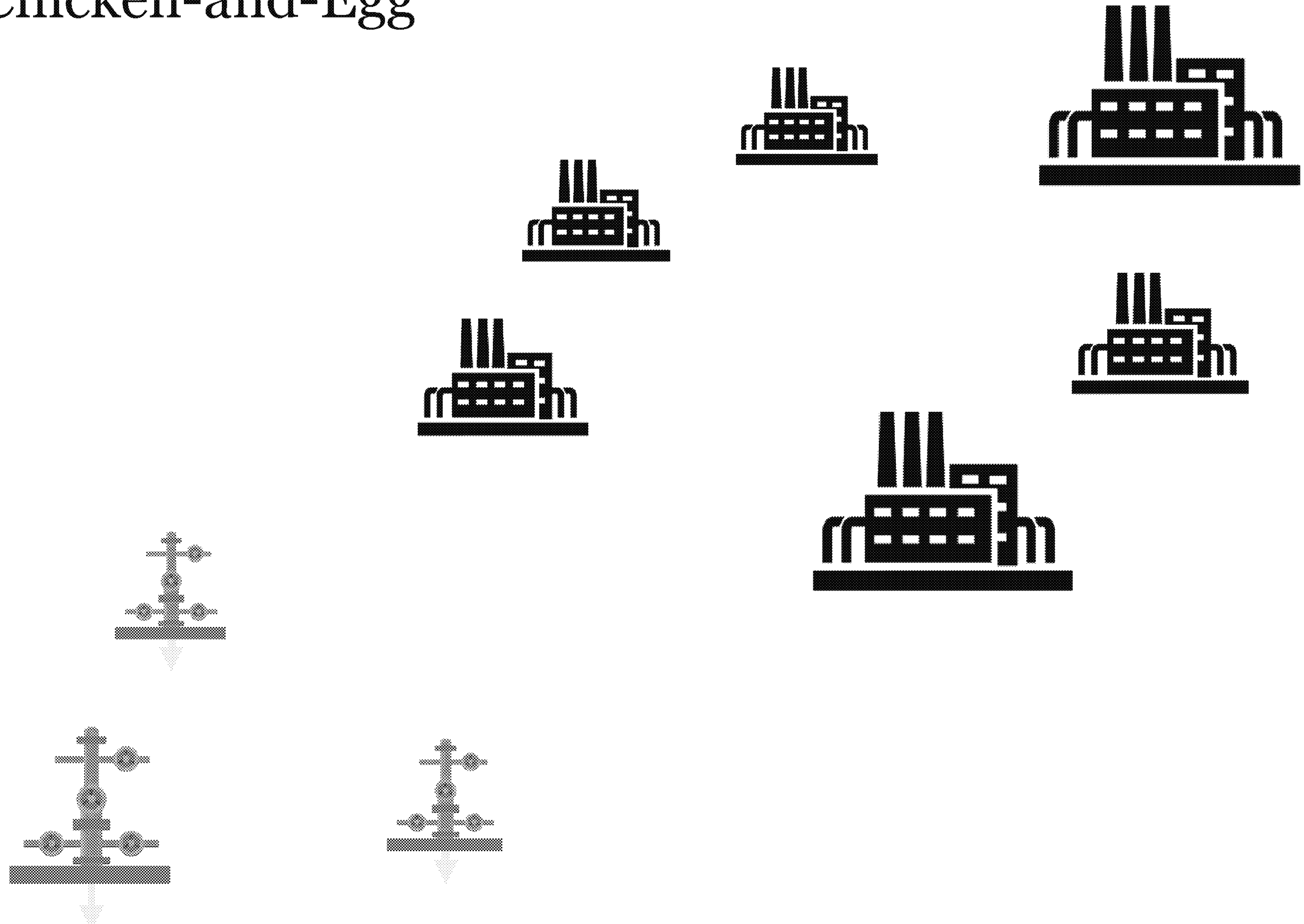
But, There Are Critical Barriers to Deployment

1. Cost / capital intensity

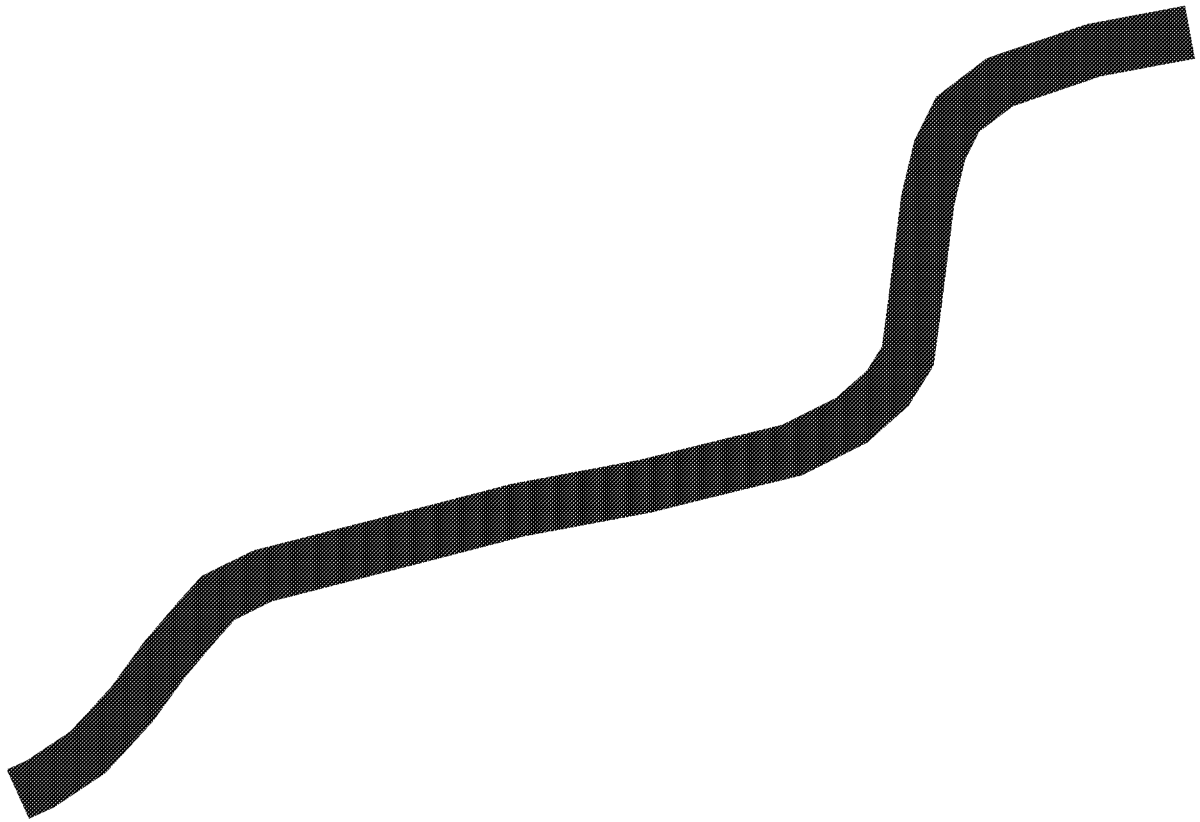
2. Chicken-and-egg

3. Economy of scale / first-mover disadvantage

Chicken-and-Egg



Chicken-and-Egg



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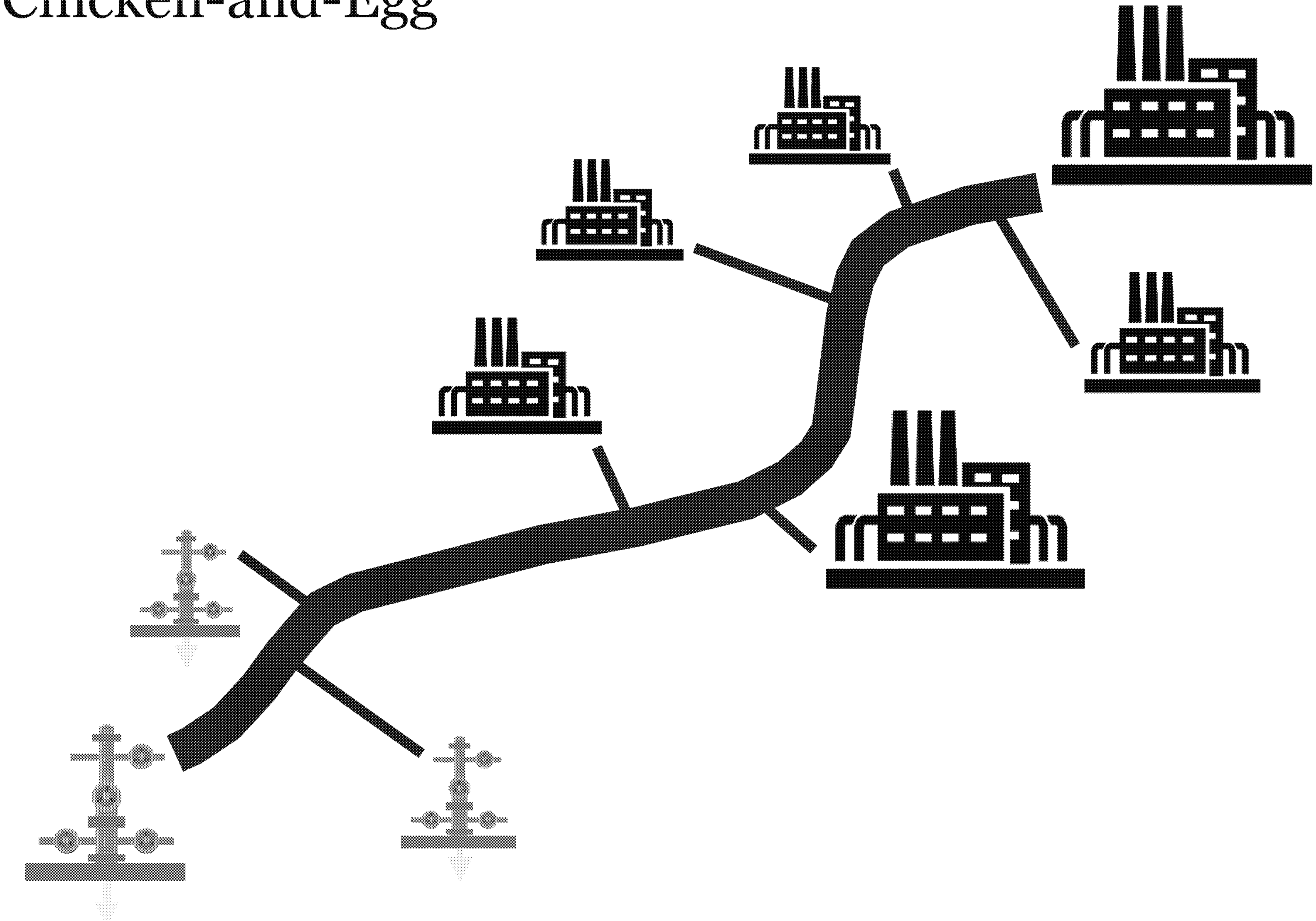
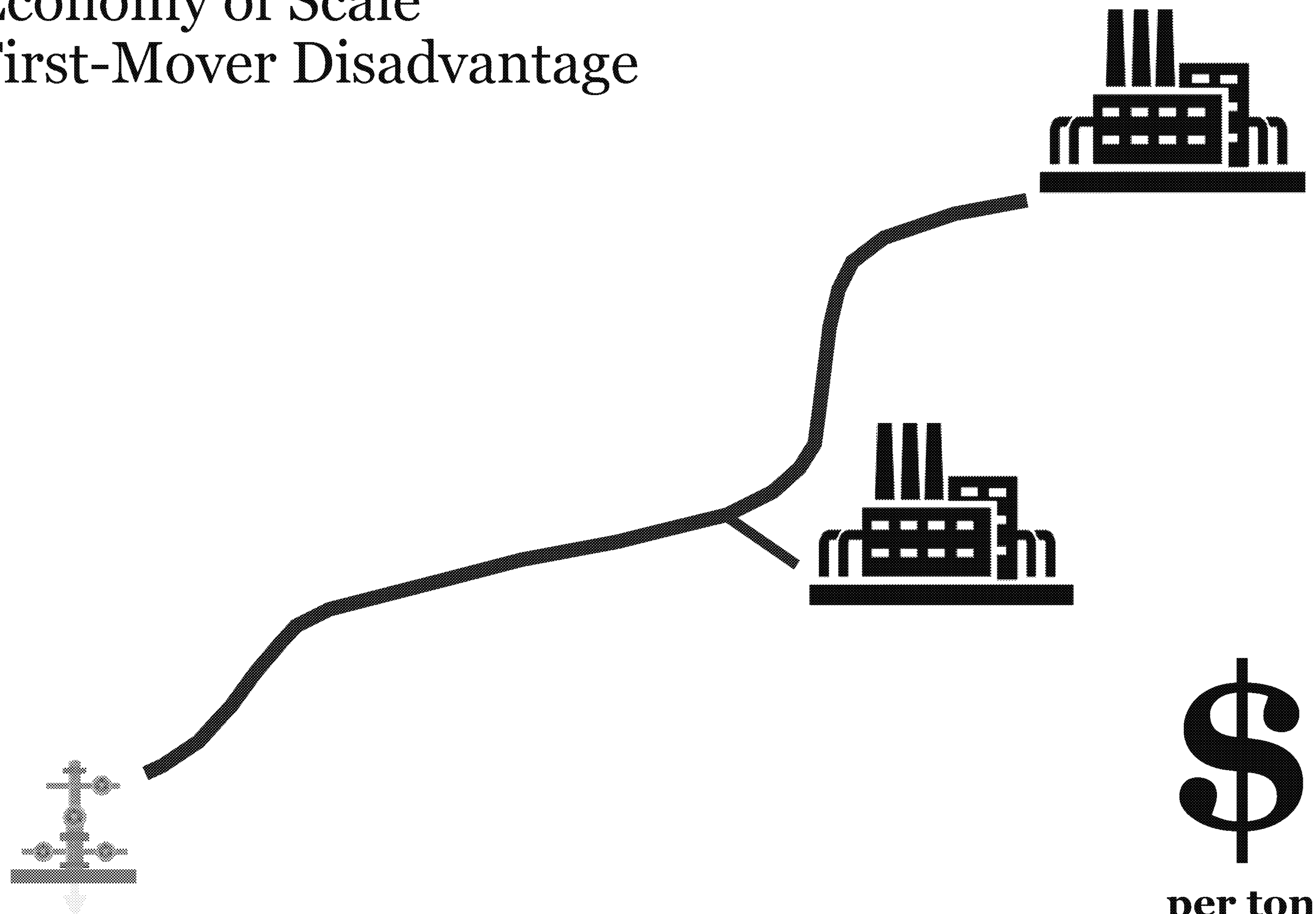
Chicken-and-Egg



Economy of Scale
First-Mover Disadvantage



$

per ton

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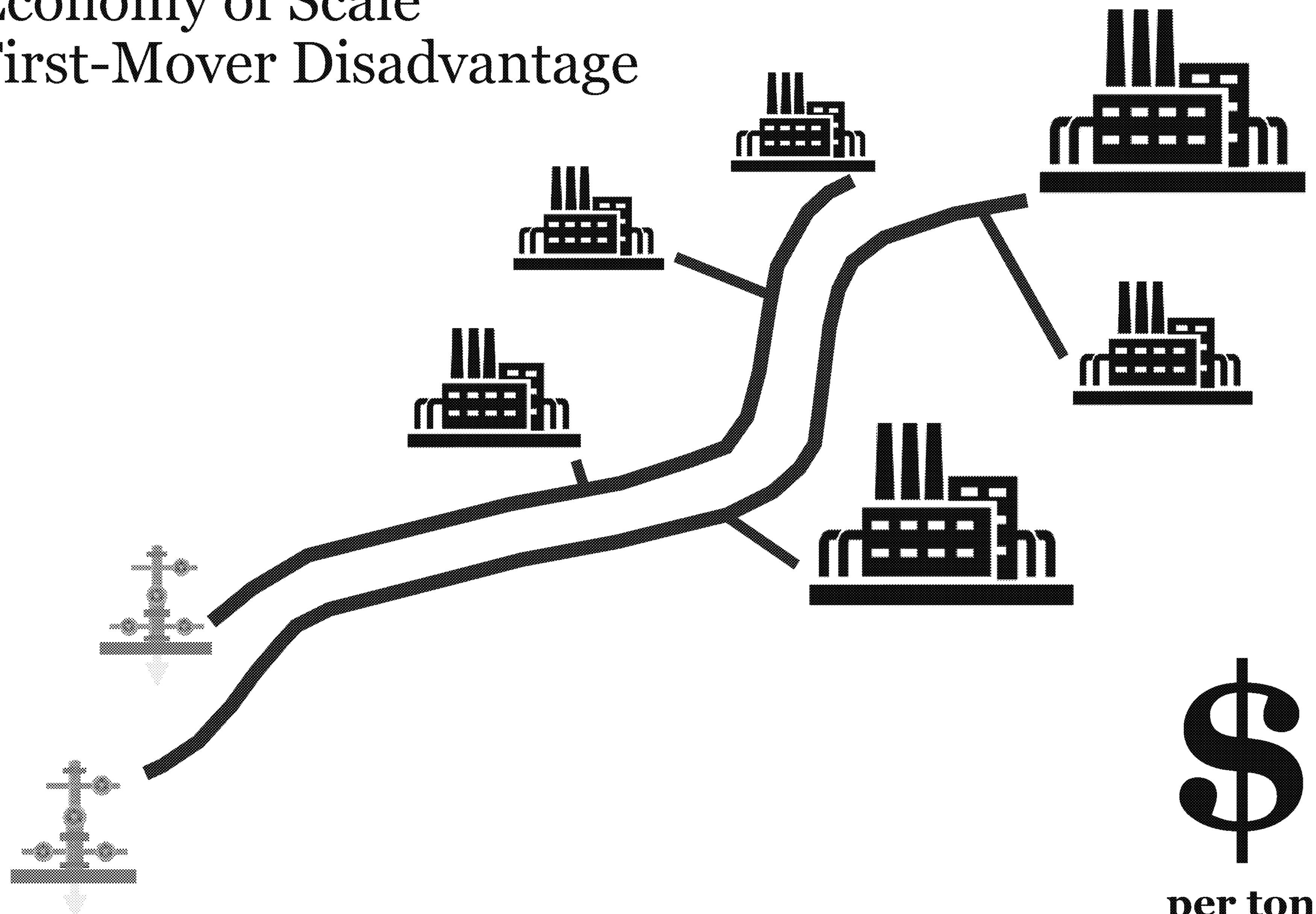
Economy of Scale
First-Mover Disadvantage



$

per ton

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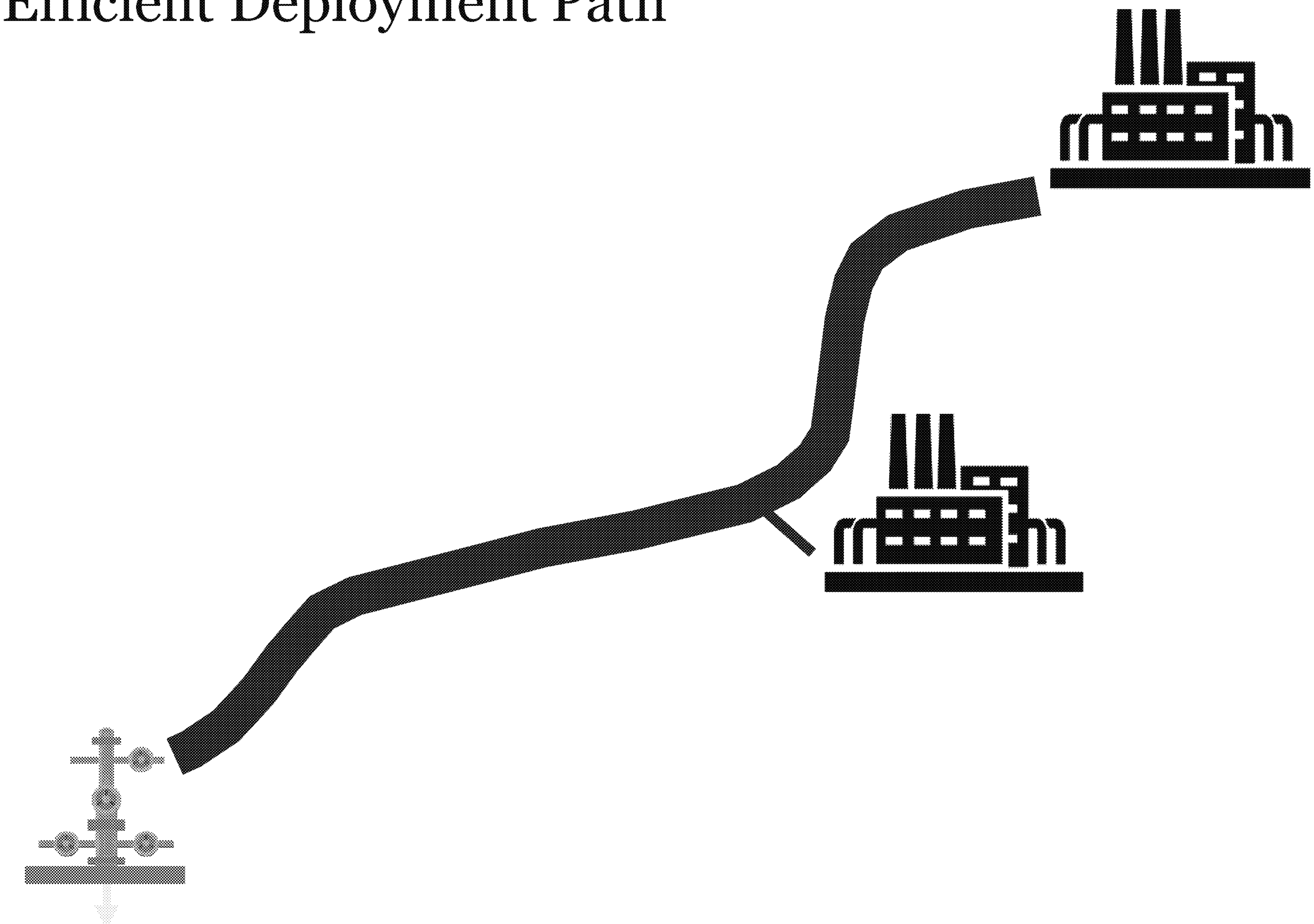
Efficient Deployment Path



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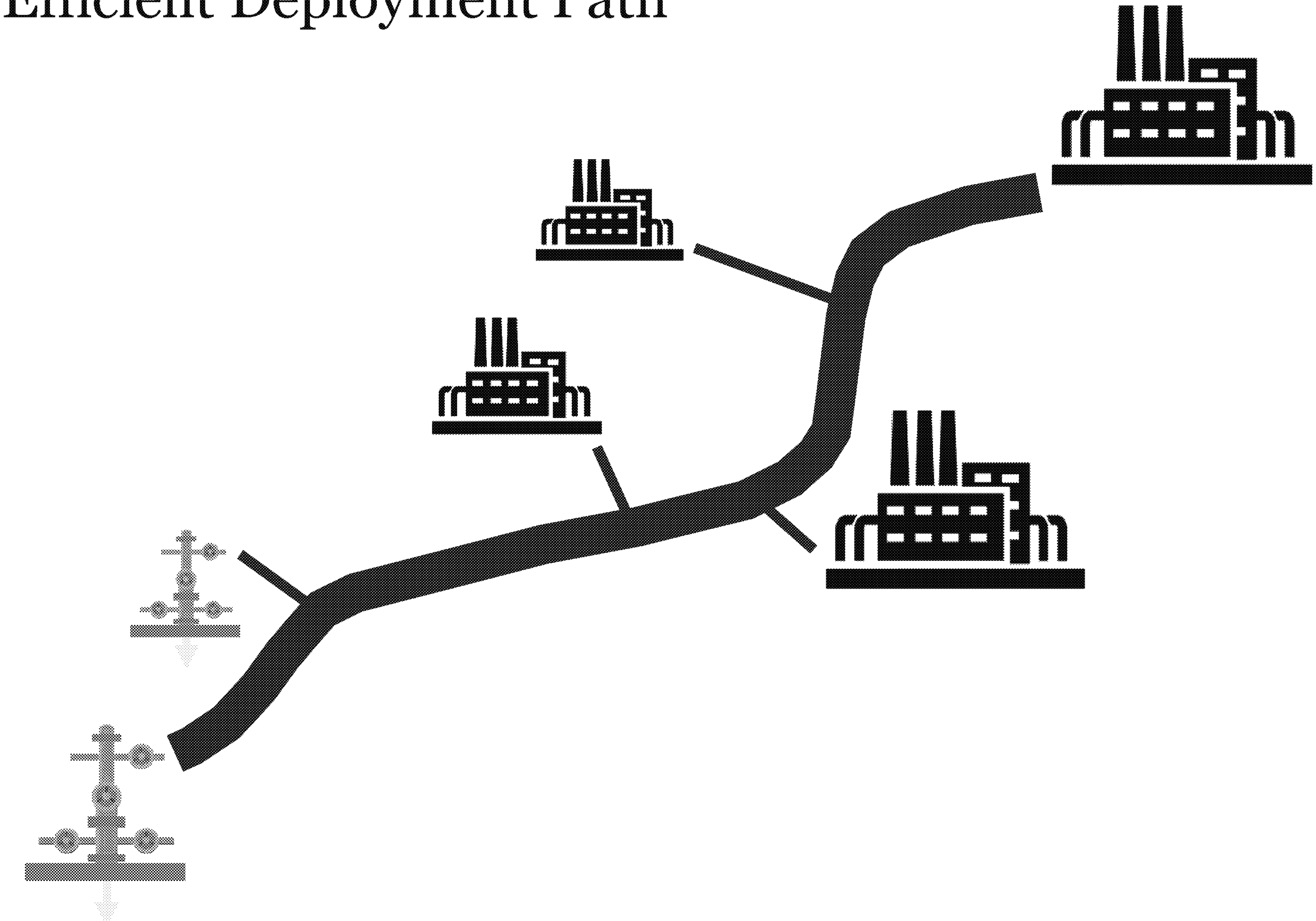
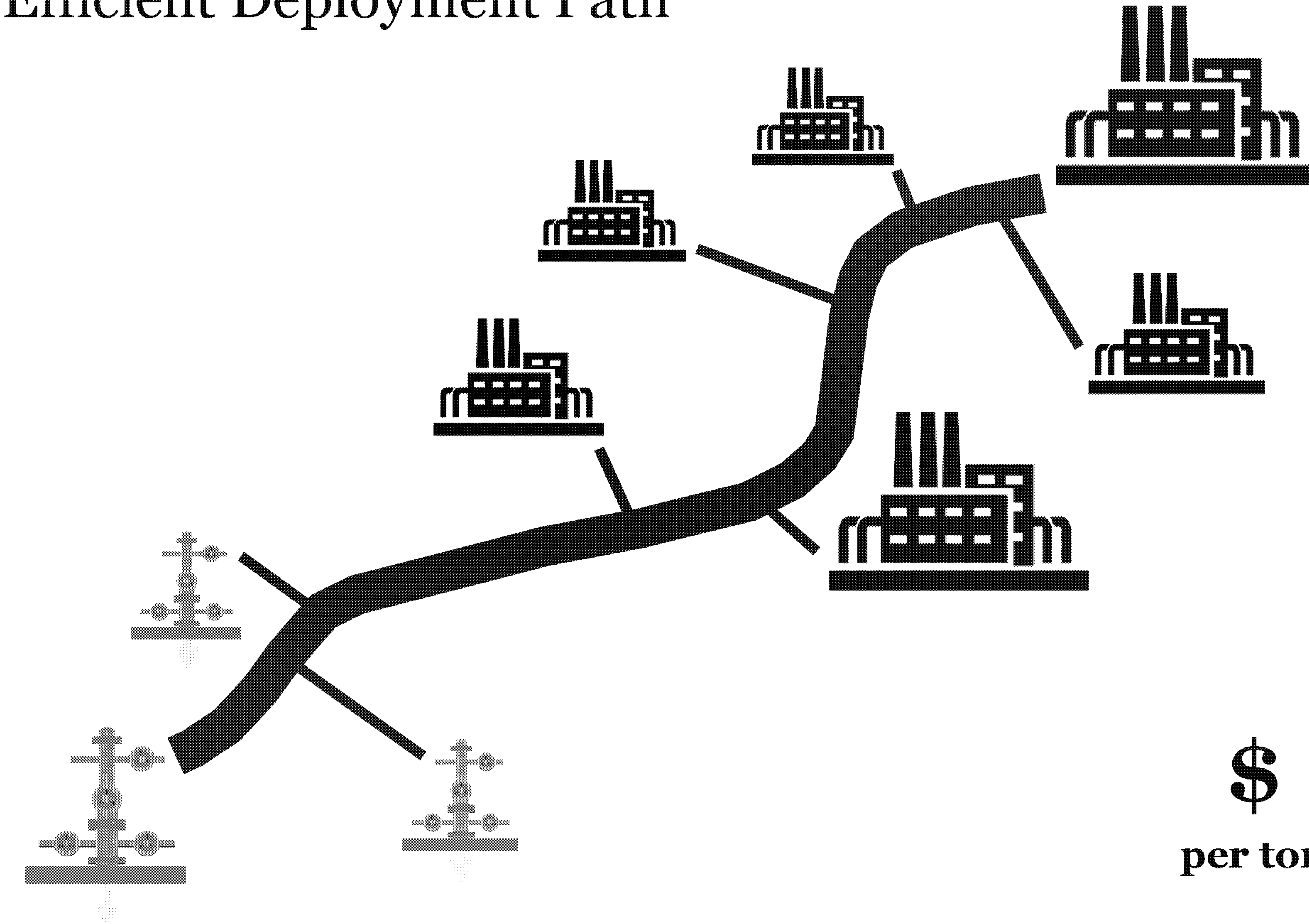
Efficient Deployment Path



Efficient Deployment Path



$

per ton

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Essential Role for Government Policy

1. Reduce financing cost
   - e.g. federal infrastructure loans

2. Overcome chicken-and-egg
   - e.g. flexible payback loans

3. Ensure sufficient scale
   - e.g. grants for additional capacity in new pipelines

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Government Policy Support for CO_2 Infrastructure

- European Union
  - EU Green Deal, Five Projects of Common Interest, Norway Northern Lights
- Canada
  - Alberta CO_2 Trunk Line recently completed with substantial government funding
- Australia
  - Government is leading development of a CO_2 trunk pipeline and storage system
- United States
  - 2015 DOE Quadrennial Energy Review recommended financial incentives for CO_2 pipeline infrastructure

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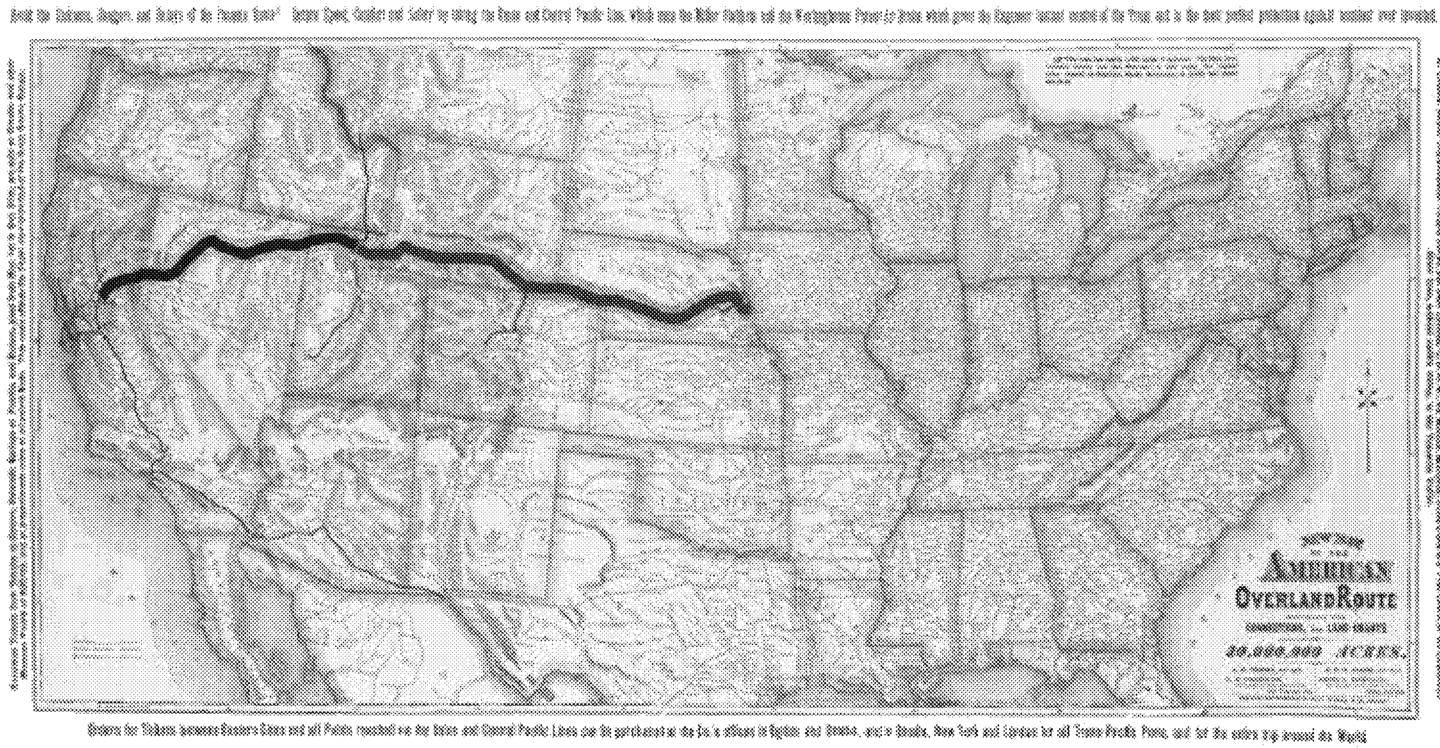
Past Example: First Transcontinental Railroad



- Completed in 1869; opened up the west
- Enabled by federal government loans and grants (land grants)

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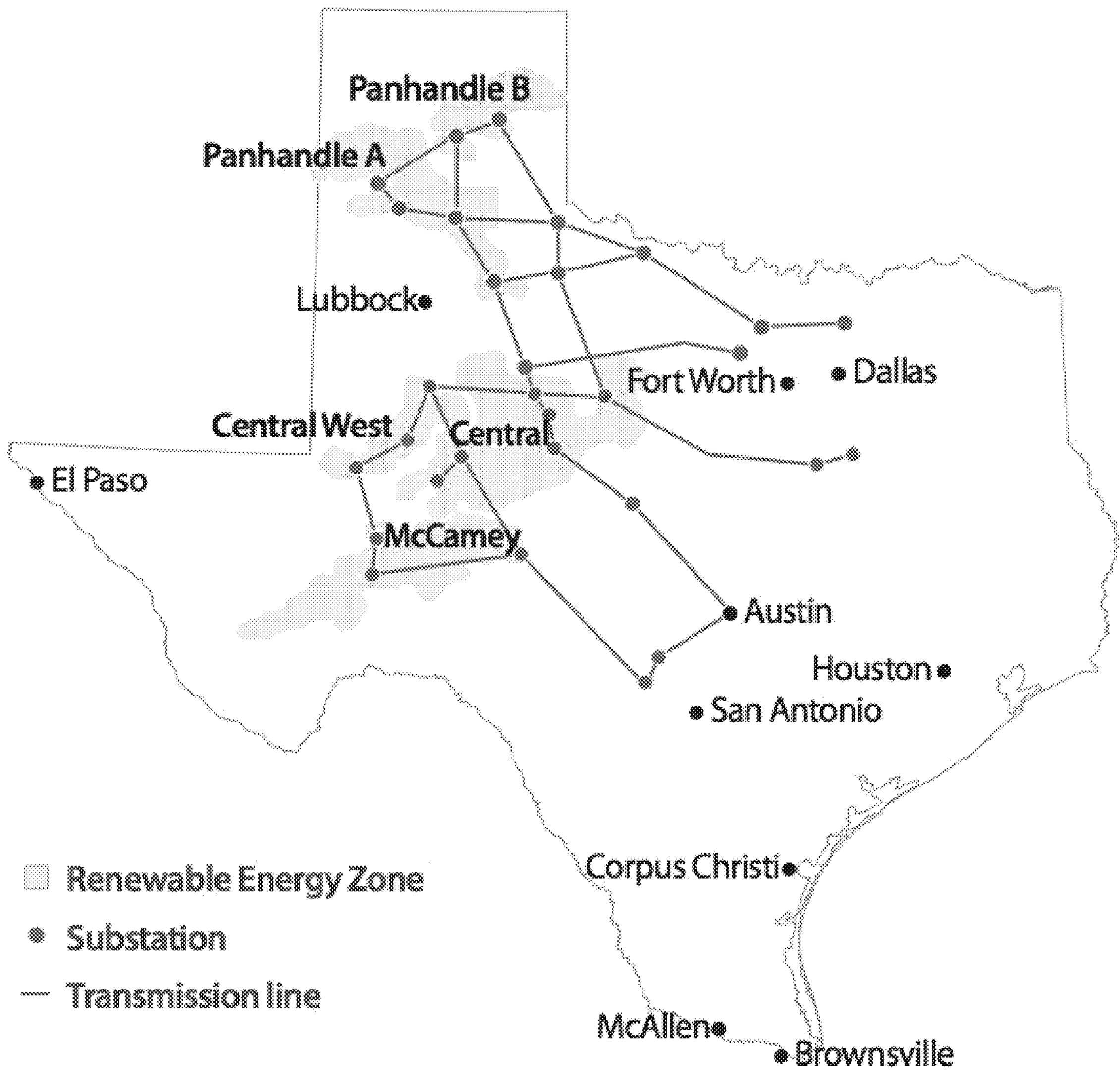
Past Example: Texas Wind Energy

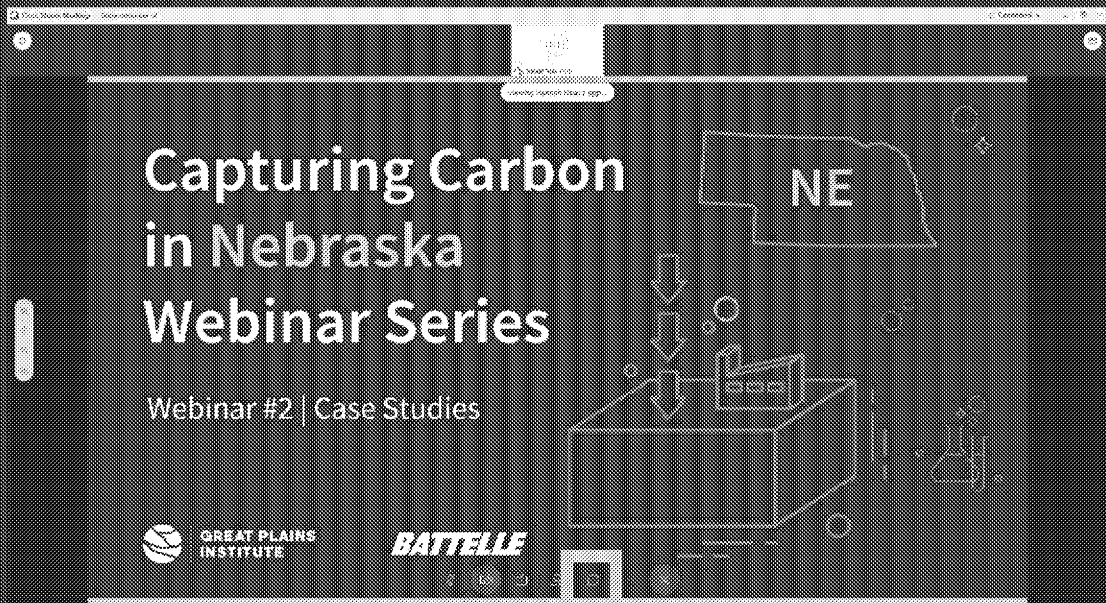


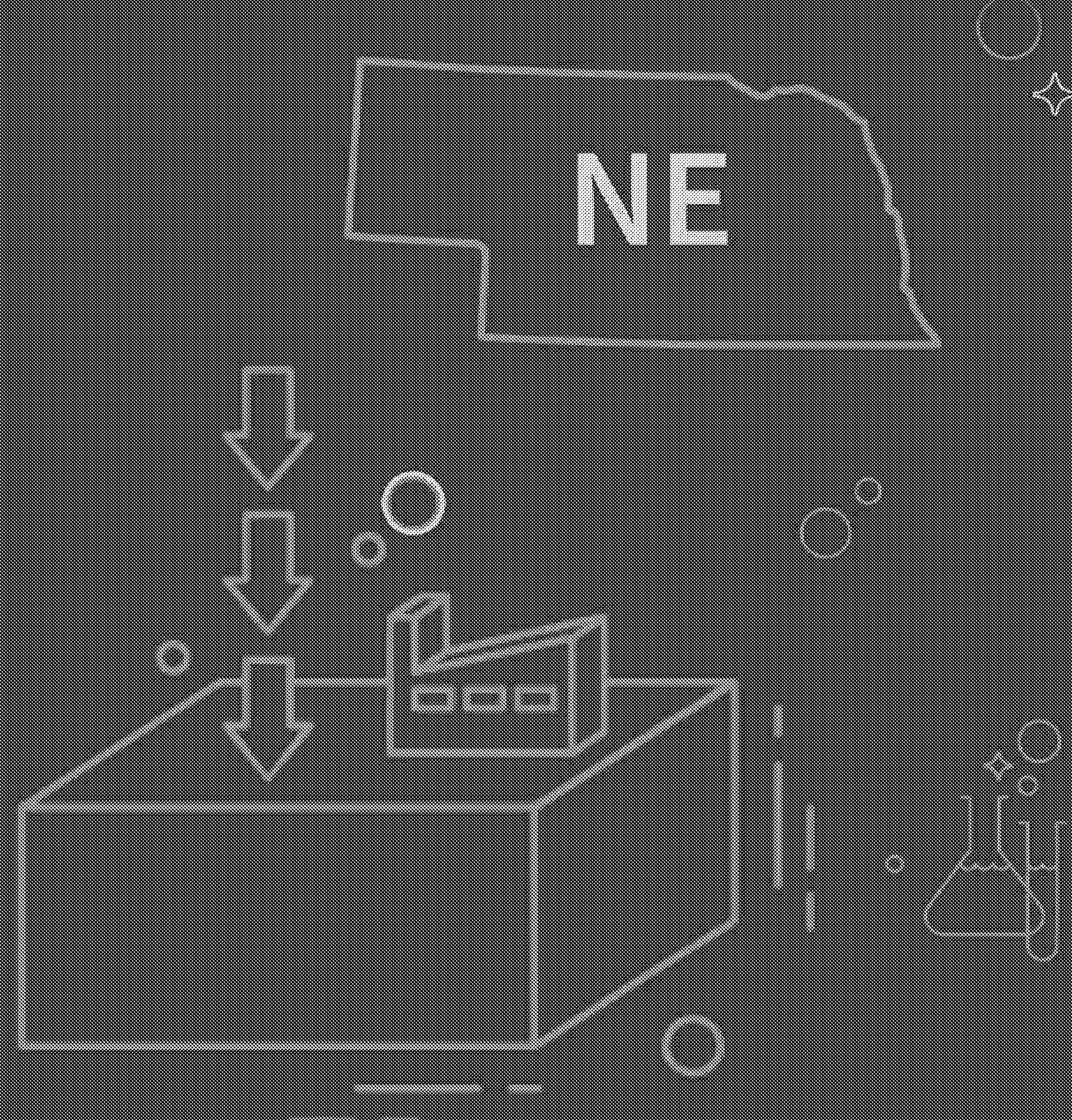
https://www.nrel.gov/docs/fy16osti/65988.pdf

- Texas: wind resource in west; population in east
- Wind PTC (45Q analogue) mid-2000s
- Chicken-and-egg problem
- Texas state government mandated, planned, guaranteed financing for new transmission network

QUESTION & ANSWER

Submit your questions for the panelists via the chat feature in WebEx





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    - Prospects for carbon capture
    - Prospects for enhanced oil recovery
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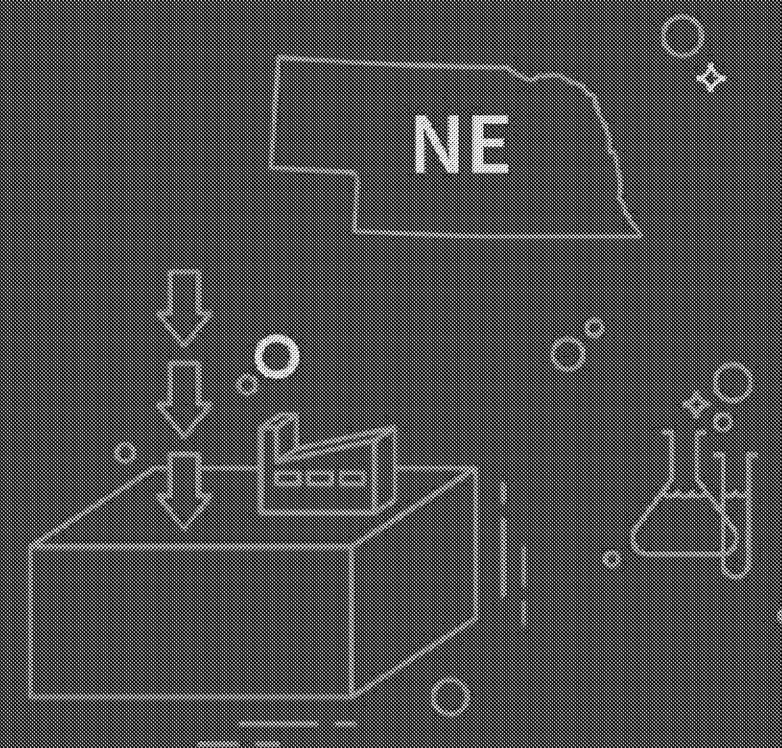
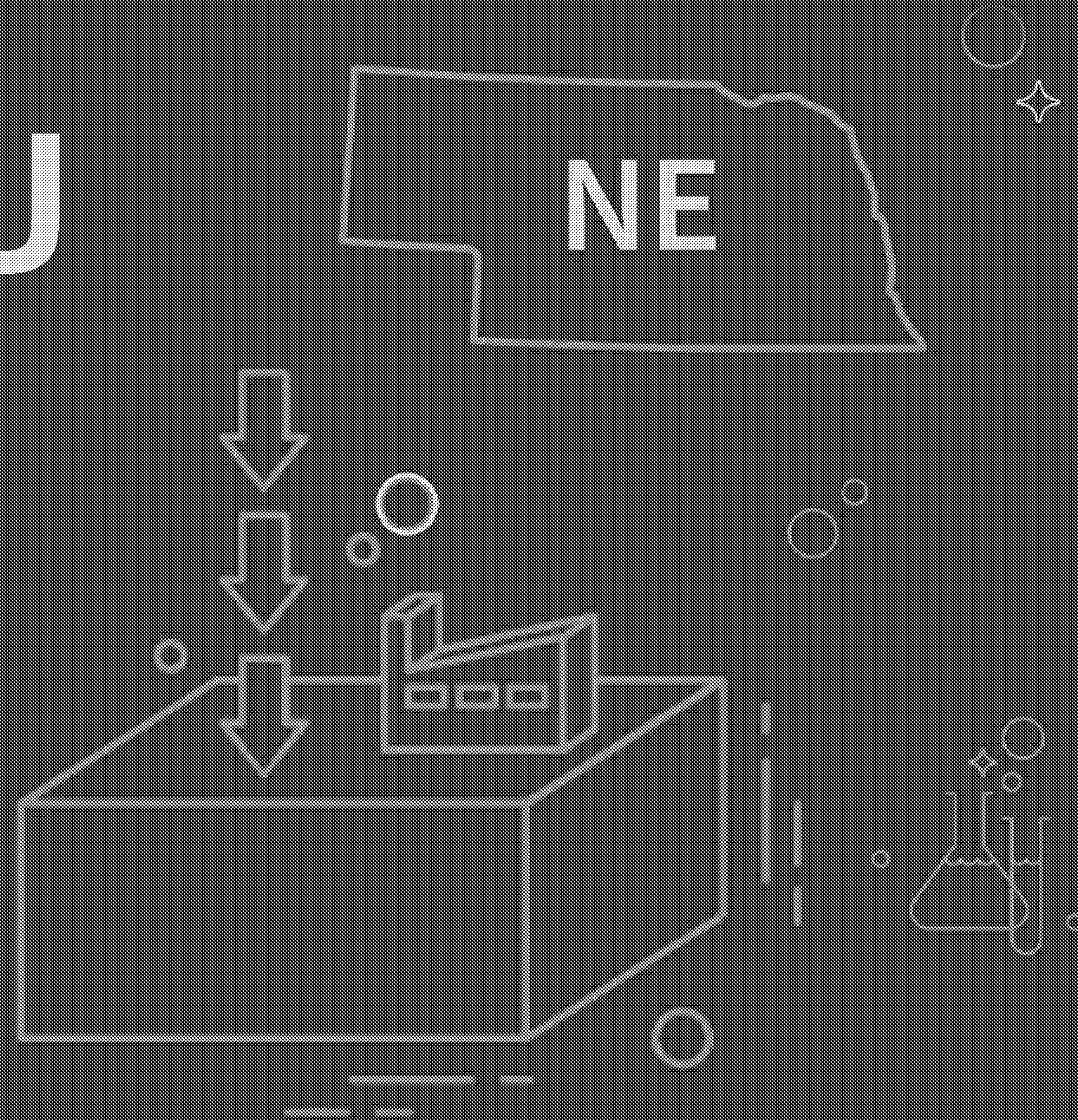


THANK YOU



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